THE FUTURE OF THE SOVIET MARITIME FLEET: A METHODOLOGICAL APPROACH UTILIZING SELECTED FACTORS FOR PREDICTION

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THESIS

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SELECTED FACTORS FOR PREDICTION

by

Thomas James Martin

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I. INTRODUCTION

A. THE OBJECTIVES OF THE STUDY

The Merchant Marine of any major nation comprises an important portion of its sea power. In the years since World War II the USSR Merchant Marine has grown at a phenomenal rate and become a top contender for worldwide maritime trade.

Shipbuilding (or ship-acquiring) in the USSR is a planned industry, that is, the acquisition of merchant ships occurs in accordance with some centrally determined plan and not in response to purely economic stimuli.

As there are political and military advantages inherent in the possession and deployment of merchant ships, it is logical that political and military factors are introduced in the planning of their procurement.

This investigation will determine the nature of the relationships between some key variables representing economic, political, and military factors in planning the merchant force; the numbers, size, and types of ships added to the merchant fleet.

Economic motivating factors are primary in the planning of the Soviet Merchant Fleet [Athay; 1969, p. 4]. However, economic advantages have from time to time been held in abeyance in order to further military and political aims. One Soviet publication reports; "The Russian Maritime Fleet is to be considered as a weapon in the competition with the capitalist countries, and it must contribute towards breaking

the expansion of certain capitalist countries in the framework of world merchant shipping, in order to support the developing countries." [Soviet Merchant Ships, 1969, p.x].

With regard to the military contribution of the Merchant Marine, Admiral King said, "No maritime nation has ever been able to fight a war successfully without an adequate Merchant Marine." [Anderson; 1945, p.10]. Although meant to describe a large long war such as World War II, this statement has equal if not greater application to the Cold War situation. The prime importance of a capable merchant force in the distribution of military aid or in the support of a limited war, such as Vietnam, has been demonstrated. Even in a nuclear holocaust the probability of survival of active merchant ships has been estimated to be between 50% and 75% [Jenson; 1966, p.25-27]. The surviving ships could certainly play a critical part in any continued wartime operations.

There are political and idealogical bases for the development of a large merchant force by the USSR. Internal to the Communist Bloc, Soviet dominance of trade is enhanced by the economic advantages inherent in maintaining a large merchant fleet. Therefore, the primacy of the Soviet system is reinforced. External to the Communist Bloc the political influence of the Soviets is improved by their ability to provide shipping to many developing nations. It has been hypothesized that the recipients of economic aid (and to an extent the participants in trade) become dependent; this acts as an effective extension of control [Magdoff; 1969, p.117].

The end result of this investigation will be the development of a methodology by which some economic, political, and military measures can be utilized to predict the composition and size of the future Soviet Maritime Fleet.

B. THE CENTRAL QUESTIONS OF THE RESEARCH

The major questions to be answered focus on the goal of predicting the future size and composition of the Soviet Maritime Fleet.

1. What are the key variables in predicting merchant ship acquisition in the USSR? How do these compare with the other major maritime nations of the world?

2. What are the relative weightings and expected variations of each of these key factors?

3. In recent years, most major maritime nations of the world have developed larger and more specialized ships while, in general, the Soviets have maintained a fleet of small and unspecialized vessels. With respect to this phenomena, the following questions reflect the direction of this investigation.

   a. Are there political reasons which are more important than economical motives for Russia maintaining a force of relatively small ships? More specifically, do Russians build small ships in order to accommodate Third World countries?

   b. Can the Russians be expected to build more and larger supertankers?

c. What will be the characteristics of future Soviet merchant ships? How do these compare with characteristics of other major maritime nations?

d. What will be the nature of the fleet mix, the percentage of tankers, bulk carriers, and freighter ships making up the fleet?

These general questions later were couched in terms of more specific hypotheses for the purpose of statistical testing.

C. THE GENERAL METHODOLOGY AND ORGANIZATION OF THE STUDY

The methodology used was twofold. First, a survey of the literature provided general background and a preliminary analysis of Soviet merchant shipping was conducted on the basis of historical generalizations. This analysis was made with the dual intent of (1) description and explanation of the Soviet maritime history and (2) determination of those variables which would best represent key predictive factors of Soviet merchant shipping.

The second methodological approach was a statistical analysis of selected variables in order to describe, explain, and predict Soviet merchant shipping development. The steps of this analysis enumerated below in general terms are described in detail in the <u>Methodology and Results</u> section.

The initial step of this research was to state the problem to be addressed and the central questions about which the study was to revolve. Once these questions were couched in terms of statistically testable hypotheses, the next phase

was the choice of measures or indicators to represent the key concepts to be tested. The primary source of information for the operationalization of the variables was the historical non-quantitative analysis previously completed.

The operationalization of the variables used in this research is explained in detail in a later section. The comments below provide some general background for the selection of these variables.

Three central concepts emerge when considering the dependent variable, The Merchant Fleet. The first, the Overall Size of the Merchant Fleet and Fleet Components, is of primary interest to the planner concerned with the maritime power of a nation. Both the total numbers of ships and the carrying capacity of a merchant fleet aid in the definition of economic, political, and military potential. The subdivision of the fleet by major ship types, i.e., tanker, bulk, freighter, and combination passenger ships, allowed further definition and testing of this first dependent concept.

The second major dependent concept to be operationalized was the Average Ship Characteristics. In addition to merely describing the ships of a fleet, this concept is useful for testing the various hypotheses dealing with those characteristics of specifically military or political benefit.

The third major dependent concept of the research was the Fleet Mix. The percentage of ships of a fleet of a given type could be indicative of political, military, or

economic motivations and the outcome of conscious policy decisions. The differences of relative composition among the major maritime fleets of the world with respect to particular trends should give insight into their future composition.

The independent concepts fell into 3 general domains - military, economic, and international political. These categories were not exhaustive (e.g., sociological and internal political domains were not tapped), nor were they mutually exclusive (development and demographic factors influence both the military and economic spheres, trade influences both economic and political domains); however, they do represent the major factors most likely to affect merchant shipping.

In order to operationalize the domains, they were first subdivided into concepts as diagrammed in Figure I-1.

Once the concepts were operationalized, the data was collected and put into machine readable form and a computer file was created. The SPSS package provided the necessary programs for conducting the statistical procedures for this research.

The initial task of the analysis consisted of examining and describing each measure, obtaining the mean, standard deviation, etc., of the aggregate data set as well as the same values broken down by individual country. Graphic analysis of each dependent variable across time was conducted.

THE INDEPENDENT CONCEPTS

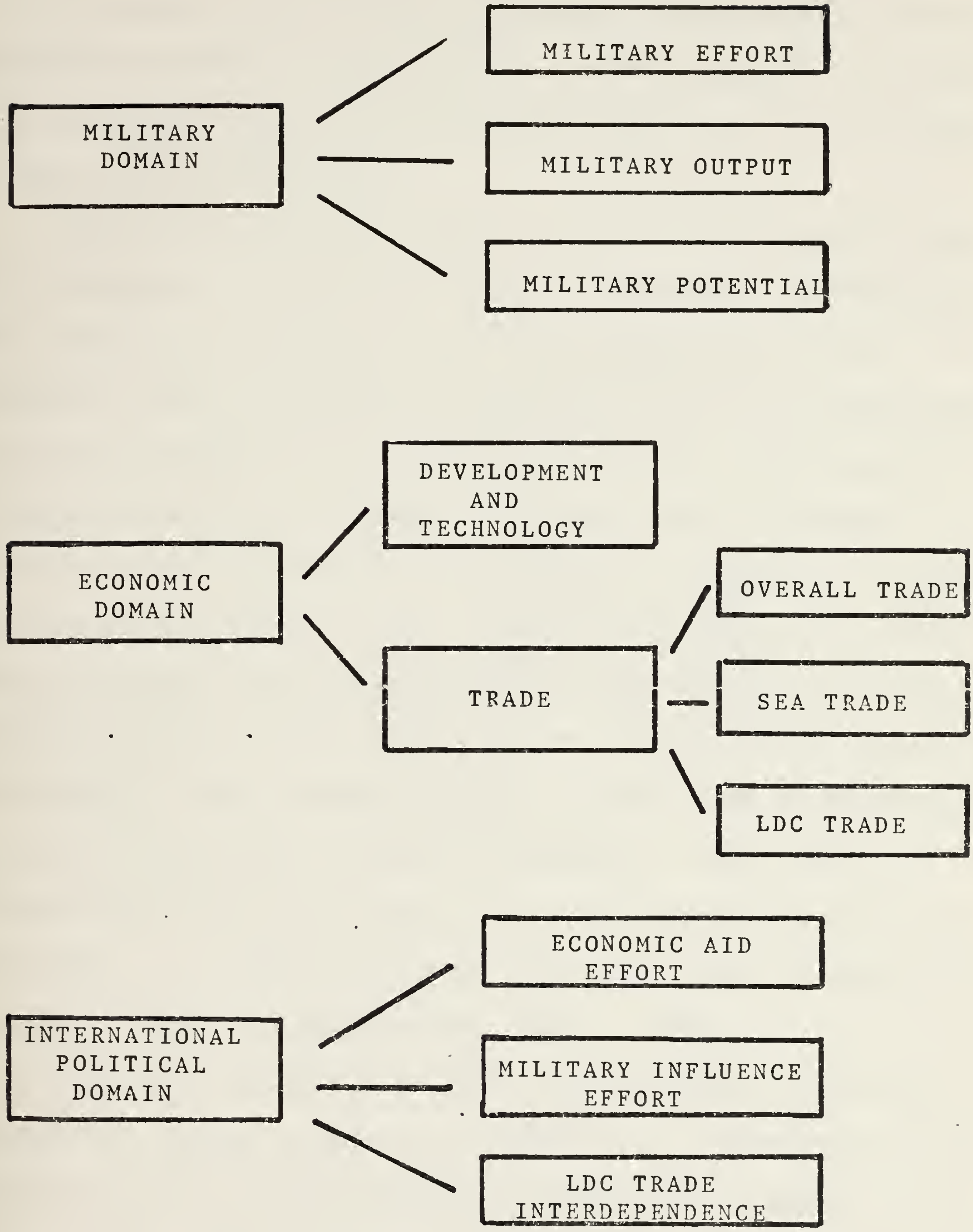


FIGURE I-1

The next step in the analysis was a description of simple relationships or correlations between the dependent and independent measures. This represents a step <u>toward</u> explanation and prediction but empirically represents only a covariance within each measure-dyad.

The third analytical step is that of data reduction of the independent variables. This is a necessary preparation for subsequent analytical techniques where only a few variables can be logically manipulated due to the constraints of machine capability and multicollinearity. Some statisticians suggest that stable regression results are not possible with more than five independent variables. Although this represents the extreme, "Keeping the number of independent variables within a reasonable limit does help in the interpretation of the results and in making the analysis more meaningful. What should be kept in mind is that each added variable sacrifices a degree of freedom. Each degree of freedom sacrificed increases the size of standard error of estimate . . . and thus reduces the likelihood of significant results," [Rai and Blydenburgh, 1973, p.220].

There were two basic methods used to reduce the number of variables, factor analysis and modeling. The object of factor analysis is to determine which measures vary together. This allows the grouping of many different variables into a few key measures which represent empirically demonstrated strong relationships within the group and are distinctly separated from any other group or key variable in another factor. In

the words of Rudolph Rummel, the technique's most active proponent, "It takes thousands and potentially millions of measurements and qualitative observations and resolves them into distinct patterns of occurrence," [Rummel, 1967, p.445]. A comprehensive discussion of factor analysis is available in the works of Rummel [Rummel, 1972, p.34-65]. Additionally, the results of the factor analysis allow the utilization of multiple regression analysis without hazarding the error of multicollinearity. Multicollinearity is the error resulting when two or more highly correlated measures are used to cumulatively predict to the dependent variable. Figuratively, it is a multiple counting of the same variable. The error, if committed, results in an erroneously high R (multiple correlation coefficient) and correspondingly high R^2 (coefficient of multiple determination). A more comprehensive discussion of the problems and treatments of multicollinearity can be found in the works of Gurr [Gurr, 1972, p.155, 169].

While factor analysis represents an inductive approach to data reduction, the alternative of modeling is a method by which a few key variables are chosen by the researcher to operationalize the concepts utilized in a model. The model is created on the basis of the researchers informed but still intuitive grasp of the reality of the situation. The model is frequently constructed for the purpose of testing specific hypotheses. If the researcher is so fortunate as to have factors from a factor analysis coincide with the concepts of

THE TWO GENERAL PROCESSES OF STATISTICAL ANALYSIS

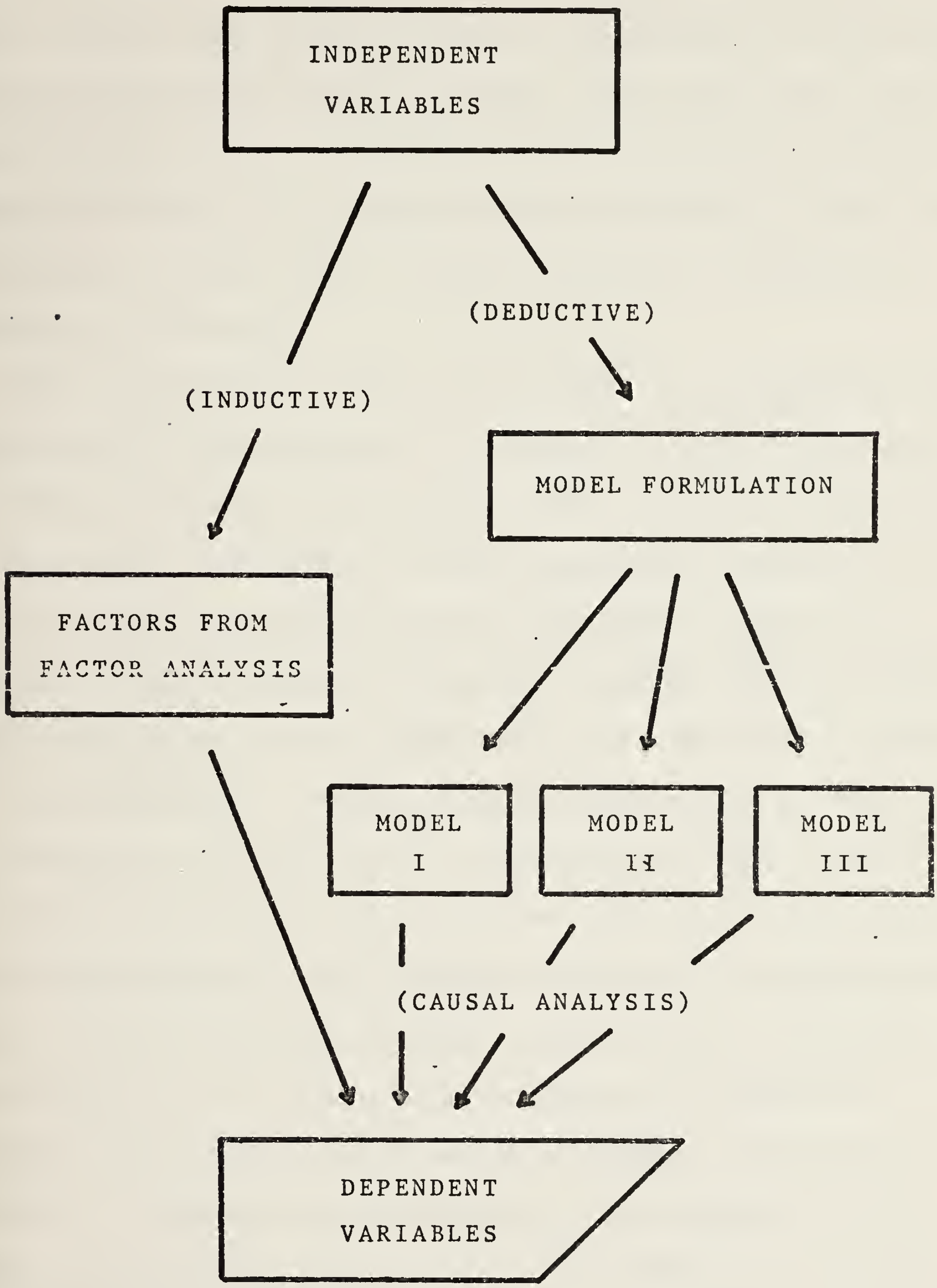


FIGURE I-2

his preconceived model, he can proceed on the basis that the model represents realistically the independent factors "at work" in the real world over the total number of variables and cases he has sampled. If such is not the case, multi-collinearity can be avoided by ensuring that the variables used in the model are essentially uncorrelated. Thus, the statistical significance of the results of a regression analysis is assured.

The fourth major step in the analysis is determination of predictive relationships. The major tool of this phase is multiple regression analysis. The results of this analysis are equations consisting of the independent measures, properly weighted with b coefficients and constants, which will predict to the dependent variables. Additionally, several other statistics are provided which give valuable information to the researcher. Whereas the b weights tell by what amount the individual factors must be multiplied, <u>beta</u> weights provide the measure of the relative degree of change effect each measure has on the dependent variable in standardized terms. This statistic frequently corresponds to the partial correlation of the individual variable but Herbert M. Blacock, Jr. distinguishes between partials and betas as follows: "The partial correlation is a measure of the <u>amount of variation explained</u> by one independent variable after the others have explained all they could. The beta weights . . . indicate <u>how much change</u> in the dependent variable is produced by a standardized change in one of the

independent variables when the others are controlled," [Gurr, 1972, p.165].

R^2, the correlation coefficient of multiple determination, identifies the explained proportion of the variation of the dependent variable [Gurr, 1972, p.150]. In simple terms, an R^2 of .50 means that fifty percent of the variation of the dependent variable can be explained utilizing the given equation. Examples of the application of these coefficients are found in the methodology and results section. A comprehensive discussion of regression analysis appears in Rai and Blydenburch [Rai and Blydenburch, 1973, p.202-233].

The use of time-lagged data in multiple regression analysis led to predictive equations utilizing both the inductively derived factors and the independent operationalized concepts of the models.

As a final step in the analysis the researcher embarked on a phase entitled time-series analysis. Technically, the entire study could be termed time-series analysis in that it was a longitudinal (1950-1973) as well as cross-sectional including nine countries [Gurr, 1971, p.141]. However, this particular phase of the research focused on manipulation of the variables in terms of temporal relationships. The variables were averaged to create five year and three year averages, and their trends and changes examined. Differences in values of the same variable over two year and four year timespans were computed and used as new variables. These new variables were then divided by the average value over the

years considered and used as a direct measure of percentage change of that variable.

All of these new variables then proceeded to undergo the same procedures as had their untransformed predecessors, that is, description, graphic analysis and measures of central tendency, factor analysis, and the final analytical step, multiple regression analysis.

II. HISTORICAL ANALYSIS OF SOVIET MERCHANT SHIPPING

A. BRIEF HISTORY OF SOVIET MERCHANT MARINE

1. Tsarist Maritime Efforts

Russia has always been a natural land power much as Great Britain has been a natural sea power. In early Tsarist Russia not so much as an approach to the seas of the world existed until Peter the Great gained access to the Baltic in 1703 [Butler, 1970, p.20]. Peter the Great, sometimes called the Father of the Russian Navy, drove the Swedes from the River Nieva to secure for Russia her first access to the Baltic Sea. Peter the Great also drove the Turks to the sea of Azov; but it wasn't until 1770 that Catherine the Great had a significant victory over the Turks at Tchesme in Aegean. The result of this victory was the signing of the treaty of Kuchuk-Kaindardzhy which granted the Russians free navigation of the Black Sea and the right of passage through the Bosphorus and the Dardanelles [Fairhall, 1971, p.20].

There was little interest in maritime activities to follow the early Tsarist Imperial ventures. The Russian nation was expanding eastward into the Asian wilderness much as the U.S. expanded to its west. The importance of rail transport in this effort was stressed by lobbyists in the Tsarist court to the detriment of the role of maritime transportation. The trans-Siberian railway was, in fact, completed just in time for the Russo-Japanese War; however, this was

little help for the naval battles of this war in which the Russian Navy was obliterated.

At the time of the Russo-Japanese War, the main governmental shipping activity was the Volunteer Fleet established in 1876 "to give Russia maritime power." In 1904 this merchant service contained fewer than 25 ships, most of which were built in the 1860's and 1880's. Additionally there were some ten likewise aging vessels from the semi-private Black Sea Navigation Company [Harbron, 1963, p.169]. As a result Russian merchant shipping was unable to adequately assist its own naval fleet. This factor was crucial during the heroic journey that Admiral Rodzhestvensky made in an attempt to rescue the remainder of the Russian Imperial Fleet trapped at Tsushima. During this spectacular 12,000 mile trip from the Baltic Sea, Russian Naval ships were dependent on foreign chartered colliers for fuel. Many delays were caused by dickering with these profit conscious ship owners when time was of the utmost importance [Harbon, 1963, p.169]. The subsequent loss of this battle was the decimation of the Russian fleet.

During the last 20 years of Tsarist rule administration of the merchant marine was marked by indifference and a complete lack of planning [Harbron, 1963, p.169]. One achievement, however, stands out. That achievement is the experiment of the Artic icebreaker in the 1890's, which was promoted by Admiral Makarov. This was a victory over not only the environmental elements, but also the elements of leadership indifferent to maritime matters. The successful results of

this effort soon made Russia the world's leader in ice navigation and stimulated further northern exploration. To this day Russia has continued to lead the world in number and modernity of icebreaker ships [Fairhall, 1971, p.24-27,32].

By 1914 the Merchant Marine consisted of a half-dozen private and semi-private companies. Russia owned about 1.5% of the world's merchant ships, one third of which were still under sail [Harbron, 1963, p.140].

At the time of the revolution in 1917, most of the Russian merchant ships were serving with allied navies. The Russian ships were retained by the allies of Tsarist Russia in an effort to crush the Bolshevik Regime. Additionally, other Russian ships were seized for the same purpose. Later, some of these ships were returned and formed the nucleus of the new Communist State's Merchant Marine.

2. <u>The Communist Revolution and Interwar Years</u>

By a decree of February 5, 1918, the new Soviet government nationalized all shipping companies and their assets [Butler, 1970, p.2]. However, during the inevitable chaos of the civil war of 1918-1921, most of the merchant ships which had not previously been captured rotted or rusted in the ports where they lay [Harbron, 1963, p.140]. By the time the fleet was counted in 1922, it was found that only about a fifth of the steamers and about one tenth of the sailing vessels had survived in Soviet control [Fairhall, 1971, p.79].

In 1921 Stalin had announced the New Economic Policy which made some concessions to private ownership and promoted certain economic ventures. This plan was an effort to bolster the then flagging economy of the new communist state, but it did little for merchant shipping. The first five year plan lay major emphasis on the creation of naval ships in Soviet shipyards. The result was that ship building orders of significant magnitude were placed on shipyards outside the USSR for merchant ships.

The second five year plan called for more merchant ships to be built in home yards [Harbron, 1963, p. 147]. The building and delivery of ships takes time, however, and even with the rapid growth plans of the new Soviet state, as late as 1931, less than 4% of Russia's exports were carried by her own ships. After 1937, the effects of the early five year plans became evident as Russian ships carried nearly 50% of their own trade [Harbron, 1963, p. 130]. According to Lloyd's register the Russian fleet grew from 412,459 tons in 1921 to 1,217,907 tons in 1936, an impressive growth rate during years of world-wide economic depression. Sixty percent of the new tonnage was built in Soviet shipyards [Harbron, 1963, p.141].

3. <u>World War II: The Net Effect, A Boon to Merchant Shipping</u>

Soviet Merchant Marine losses during World War II were negligible and were more than compensated for by gains from German and Italian reparations combined with American lend-lease bottoms [Harbron, 1963, p.143]. Russia received almost 1/3 of the surviving merchant tonnage of the Third

Reich and this amounted to some 173,000 tons. This tonnage consisted mostly of 300-400 ton tramps which were well-suited to Russia's needs. Additionally, Russia received about 90 lend-lease American freighters and Liberty ships. In 1946 Russia had mustered a total of about 2.4 million tons, a net increase of some 300,000 tons over her 1940 totals. Although many of the ships were aging or obsolescent, they provided a basis for the expanding economic endeavors of post-war Russia.

While the current inventory of ships at the end of World War II was satisfactory, the Russian shipbuilding capabilities had been destroyed. During the war, Russia's major shipyards had been overrun by retreating armies, both Soviet and German, each determined to destroy what was left behind [Harbron, 1963, p. 126]. The factors of a satisfactory current inventory of merchant ships plus the desire to build a quickly increased naval force led to a neglect of merchant shipbuilding in the period immediately after 1945 [Harbron, 1963, p.143]. These economic plans reflect a similar pattern to the Soviet's initial five year plans.

By the early 1950's Russia's trade had expanded to the point where substantial currency reserves were being expended on foreign carriers. The rapid increase in naval ship construction had saturated the Russian shipyards. As a result, Russia had to rely very largely on other countries both inside and outside the Communist Bloc for the additions to her new merchant fleet, in fact, not until 1953 did the first post-war Soviet built merchant ship appear. For the

most sophisticated types, such as passenger liner and research ships, Russia has relied on East German shipyards. Scandinavian, Italian and Japanese tanker-builders have had the greatest influence on Russian tanker fleets. The Russians have purchased their largest number of colliers from Polish shipyards, near their large coalfields [Soviet Merchant Shipping, 1969, p.xi]. For the construction of timber carriers, Finnish yards have provided the expertise. Within this timber carrying class of ships lie the large hatch carriers, interesting because of their military applications. The presence of an unusually large hatch (greater than 50 ft.) makes possible the stowage of large equipment such as a locomotive engine or a large tank completely concealed belowdecks. The Cold War role of these "timber ships," that of carrying concealed military equipment, can not be neglected in terms of military importance. It was one of these ships, the Poltava, which was used to carry missiles to Cuba in 1962 [Fairhall, 1971, p.97].

Beginning in the mid-1950's, there was a new impetus in Soviet merchant fleet growth as Khrushchev developed his foreign policy to include economic and military aid to the Third World [Polmar, 1974, p.76]. This new role was later articulated by then minister of the Maritime Fleet, V. G. Bakayev.

> Maritime transport (in recent years) has carried out a number of responsible assignments of the Communist Party bearing not only an economic, but also a political character. Among these must be cited, as a prominent example, the part it played in breaking down the military, political, and economic blockade of Cuba instituted by American imperialism [Bakayev, 1965].

The most notable characteristic of this progressive merchant force is the small size of the individual ships. Relative to Western ships of similar classes Russian bulk carriers and tankers are considerably smaller. The table which follows represents the Soviet emphasis on smaller ships size by comparing the relative size of the ships of the U.S., U.K., and Russian merchant fleets. The contrast is even more pronounced when comparing the size of tankers. World fleet sizes provide an additional perspective for comparing these major sea fleets.

	All Types of Merchant Ships			Tankers Only		
	Million Gross Tons	% of World Fleet	Avg. Size	Millions Gross Tons	% of World Fleet	Avg. Size
USSR	13.7	6.5	2,400	3.2	4.1	8,200
WORLD	211.7	-	4,200	77.4	-	13,200
U.K.	23.8	11.2	6,200	10.2	13.2	16,900
USA	19.6	9.3	6,200	4.6	5.9	12,200

(Table extracted in part from Fairhall, 1971, page 96; 1969 figures)

A partial explanation for the smaller-size ships is the relatively small ports and straits Soviets must deal with in their home waters. Another possible explanation for pursuing this somewhat less economical means of trade (i.e., small ships with more generalized cargo capability) is that these ships serve a political or military purpose by being able to make calls at the smaller ports of developing

countries. This supposition is strengthened by the fact that although most Soviet ports could handle larger ships, the Soviets continue to build large numbers of small ships as the mainstay of the fleet. Norman Polmar suggests that these ships will increase in political importance in the years ahead:

> A most valuable aspect of the large Soviet merchant marine is the ability of the USSR to carry its foreign trade and its economic and military assistance in its own ships (as contrasted with the United States, which carries only about five percent of its foreign trade by tonnage in American-flag ships). As the underdeveloped nations of the Third World improve their economic position and become sources of revenue and raw materials, Soviet trade with them will probably be carried exclusively in Soviet bottoms. [Polmar, 1974, p.79].

A like hypothesis can be put forth for the lethargical way in which the Soviets are transforming to containerized ships. The 1971 inventory of Soviet containerized ships consisted of 2 converted ships [Heine, 1974]. There are reportedly plans to build some containerized ships, but this development still greatly lags the situation in the West. The Soviet fleet still lacks balance by Western standards: some 70% are still small dry cargo (freighter) ships and very few are specialized. The 24th Congress of the CPSU (1971) recognized this weakness and proposed continued expansion of the fleet with a new emphasis on specialized vessesl [Heine, 1974]. The full fruits of those plans are yet to be fulfilled. Of course, the major advantage of containerization is the tremendous reduction of handling time in port. The disadvantages are that flexibility in the role of that ship is reduced, and additionally, the special facilities that are

required in port to handle the containers. Both of these disadvantages have military implications as well as political meaning when considering the facilities of the Third World ports of call.

A final note should be added that the Russians appear to be moving away from the small tanker concept as the 150,000 DWT tanker Krym is already in service and plans are reportedly being made for making a 300-350,000 ton tanker. The impact of this 300,000 DWT supertanker on Russian oil transportation remains to be seen, but it is likely that such a ship is likely to trade from foreign port to foreign port because of straits and port constraints in Russian home waters.

B. ANALYTICAL SUMMARY BY MAJOR FACTORS

1. The Economic Considerations

The primary motive postulated to be behind the operation of the Soviet Merchant Marine is simply one of economics. Not having a Merchant Marine large enough to carry about one half of the nation's trade is a heavy drain on currency reserves [Fairhall, 1971, p.64]. Faced with a rapidly growing economy and international trade at the end of World War II it was expedient for Russia to build up her merchant marine. It is true that Russia could have stressed her traditional railroad transportation system but significant disadvantages appeared. First, with the countries with which Russia trades the most (COMECON Nations) cargo can be transported roughly 30% less expensively by ship than it can by rail [Fairhall,

1971, p.60]. The gains of hard currency or key currency (primarily U.S. and U.K.) are direct when transporting by Russian ships to noncommunist countries [Jensen, 1966, p.74]. The gain of hard currency is a major aim of Soviet international trade [Athay, 1970, p.4].

The Soviet Union was able to stimulate the growth of her merchant marine by several means. Primarily the post World War II massive buying program and subsequent domestic building of merchant ships led to accomplishing this purpose. One action taken by Soviet authorities was the limitation of all carriage of goods between Soviet ports to ships of the Soviet flag [Butler, 1970, p.392]. Additionally, the use of flags of convenience was forbidden. The strategy of undercutting shipping conference established rates has obtained some additional occupation for Soviet ships. The temporary economic losses can be well borne by a Soviet Steamship Authority anxious to engage new trade. An illustrative case is the Soviet attempt to enter the Australian-European Conference in 1968.

The result of all of these expansive efforts has been that the Soviet Union has gone from carrying almost none of its seaborne trade in the early 1950's to carrying more than 52% of it in 1967 [Fairhall, 1971, p.67].

A question which arises in the face of her vastly increased foreign trade is that of Russia's traditional self-sufficient stature. Although it is true that the trend in recent years has been towards greater cooperation with

non-Communist countries, the Soviet Union and the contiguous satellites retain a significant degree of self-sufficiency. Although the Communist nations stand to gain considerably by continued cooperation and expansion of trade, they are not bound by necessity to maintain these ties. When compared with the United States the USSR appears quite self-sufficient. Considering that 69 of the 72 strategically critical materials needed by the USA are imported by ship (99% by volume), the importance of a state-controlled shipping force is apparent [Ackley, 1974].

From the previous historical sketch it can be deduced that the size of the fleet in general can be attributed largely to economic factors of trade development and overall growth.

The individual ship characteristics which describe the general conditions of the fleet pose less certain ties to the economic sphere in the Soviet case. Although the average age of Soviet ships has been decreasing correspondingly with the fleet expansion, the consistently small ship size and slow speed of Soviet merchant ships presents an anomaly among the major maritime nations.

Similarly, the fleet mix of the Soviet maritime force has been described as "unbalanced" from the western economic point of view [Heine, 1974]. The continued heavy reliance on general cargo ships and the lethargic development of containerized shipping appear inconsistent with other Soviet economic indicators.

The previous discussion suggests the following general hypotheses stated in the null form to facilitate statistical testing:

1. H_o: Soviet merchant Fleet Size is not explainable by economic motivating factors.

2. H_o: Soviet merchant Ship Characteristics are not explainable by economic motivating factors.

3. H_o: The Soviet merchant Fleet Mix is not explainable by economic motivating factors.

These hypotheses are further subdivided into hypotheses for individual indicators, too cumbersome to enumerate here. Suffice it to say that such Ship Characteristics as age, speed, size, and draft were all investigated individually.

Notwithstanding the aforementioned anomalies, it can be safely said that Russia has enjoyed significant economic gains from the build-up of her merchant marine since World War II. Although the economic considerations have been briefly held in abeyance from time to time in order to further other Soviet aims, one of the overall results has been the improvement of Russia's economic status. The economics of this industry clearly have not been ignored.

2. Military Considerations

The military role of merchant shipping in general has been postulated in several different wartime situations. The great importance of the merchant marine in limited wars, such as Vietnam, is demonstrated. In the case of the USA, renowned for a massive airlift capability, 96% of the support

goods transported to South Vietnam went by ship. In a large scale (but limited nuclear) war the merchant marine would assume a similarly important role to that which it did in World War II. The probability of survival of active merchant ships in a nuclear holocaust is estimated to be about 50% to 75%. Therefore, the surviving ships would certainly play a critical part in any continued wartime operations [Lawrence, 1966, p.108].

The ability of the Soviet merchant fleet to support the Soviet Union in any major war is somewhat questionable. Their greatest problem is the locations from which they must deploy their ships. The seas to the south and the west, that is, the Black Sea and the Baltic, are blocked by narrow straits which would likely remain in control of hostile forces. Located in these oceans are the ports from which most of their support goods must flow. The far eastern ports are quite distant from the industrial centers and are plagued with winter ice. The inability of the Far Eastern Steamship Authority (FESCO) to provide adequate support for a limited conflict was shown in the Vietnam War. Although they shipped considerable material aid to North Vietnam, still more had to come from European ports [Fairhall, 1971, p.58]. A major difficulty in this effort was the time and expense involved in transporting goods across Asia by rail.

Ice, of course, is a major problem for the operation of the major Russian northern ports of Murmansk and Archangel, the latter of which is closed for up to six months each year.

Murmansk remains open only with the aid of icebreakers, and these northern areas, of course, explain the Russian emphasis on icebreakers. The strategic value of the northern routes in the utilization of icebreaker led and ice-strengthened transport convoys would be quite important to an otherwise bottled-up maritime nation [Fairhall, 1971, p.45].

The Russian Maritime Fleet has become the primary vehicle of aid to Third World countries [Fairhall, 1971, p.58]. As previously mentioned the Soviet Merchant Marine plays a significant role in providing military aid to North Vietnam. The maritime forces were the primary method in 1962 (along with other COMECON ships) of transporting military equipment to Cuba. The emulation of the U.S. in increasing military aid to developing countries in recent years cannot but enhance the importance of the military role of the Soviet Merchant Marine.

The totalitarian nature of the USSR leaves any industry at the beck and call of the government to be pressed into military service. The Merchant Marine is an ideal candidate. Soviet merchant ships can at any time be utilized for limited naval auxiliary functions. The Russo-Japanese War provides one example of merchant ships conscripted for naval use. As previously mentioned, the inability of this force to provide adequate support was a contributing factor in the defeat of the Russian forces. The growing need for extended support for naval force stretching its horizons has been, no doubt, an important factor in the overall planning of the merchant marine.

The large overall size and large number of ships of the Soviet merchant force is clearly a positive contribution to that nation's maritime power. The flexibility inherent in such a large centrally controlled force of ships is very likely a motivating factor to Soviet strategic planners.

The diversion of merchant ships from commercial duties to those of naval auxiliaries has longstanding precedent in Soviet naval exercises. Frequently, more than 50% of the replenishment of naval vessels is undertaken by merchant vessels. This secondary mission of naval auxiliary provides a possible explanation for the small size of Soviet merchants, particularly tankers. Likewise, the continued emphasis of the Soviet Fleet Mix on general cargo vessels with self-contained cargo handling capabilities represents a military asset.

The previous discussion regarding military motivating factors suggest the following hypotheses stated in the null form to facilitate statistical testing.

1. H_o: Soviet merchant Fleet Size is not explainable by military motivating factors.

2. H_o: Soviet merchant Ship Characteristics are not explainable by military motivating factors.

3. H_o: The Soviet merchant Fleet Mix is not explainable by military motivating factors.

3. Political and Ideological Considerations

There are several ideological bases that have been postulated for Russia gaining a large Merchant Marine.

First is the Communist ultimate belief that the Soviet system is the supreme form of society. The Soviet system must be superior to all other systems; Western or Communist bloc. This principle is certainly extended to the economic realm and the primacy of the USSR in COMECON is reinforced by the strength of her merchant force. As Russian policies change from earlier tendencies of maintaining hegemony by displays of force, this factor could gain increasing importance.

The political influence of the USSR external to the Communist Bloc nations has been greatly enhanced by the ability of the USSR to provide shipping to many developing nations. As is the case with military aid, other economic aid can be provided to a nation with the use of the USSR flag merchant ships, even at an unnecessary cost of making the return trip in ballast. The advantage gained is that the flag has been displayed and another small step forward for World Communism is taken. This Cold War tactic is supported by the many small cargo ships that the USSR maintains in her merchant ship inventory. These ships are unspecialized and have self-contained cargo handling capability, both of these features provide additional advantages for dealing with developing countries. As previously noted, in the future an even larger proportion of Soviet trade with developing countries will likely be carried in Soviet bottoms.

From the previous discussion consider the effects of international political considerations on the Soviet

Fleet Size, Ship Characteristics, and Fleet Mix. The general hypotheses dealing with political motivations are stated below in the null form:

1. H_o: Soviet merchant Fleet Size is not explainable by international political motivating factors.

2. H_o: Soviet merchant Ship Characteristics are not explainable by international political motivating factors.

3. H_o: The Soviet merchant Fleet Mix is not explainable by international political motivations.

C. SUMMARY

In summary, there are certainly economical, military, and political factors involved in the planning of the Soviet Maritime Fleet.

Russia was once landlocked and her leaders remained mentally landlocked, except for brief ventures, up until the Communist Revolution. The Communists saw instinctively the need for military power and showed increasing regard for sea power and the merchant shipping role in this important capability. This interest was translated into the massive growth of the Soviet Merchant Marine after World War II.

The economic motivating factors are quite important in the planning of the Soviet Merchant Fleet. However, economic advantages have been foregone from time to time on the basis of military and political goals with apparent disregard for the profit motive. One Soviet publication reports: "The Russian Maritime Fleet is to be considered as a weapon in the competition with the capitalist countries, and it must

contribute towards breaking the expansion of certain capitalist countries in the framework of world merchant shipping, in order to support the developing countries," [Soviet Merchant Ships, 1969, p.ix].

The political and military advantages of maintaining many small unspecialized ships in merchant service has appeared to weigh more heavily up to recent years than the economy of size being pursued by Western countries. The development of Soviet supertankers and container ships may in fact serve only to augment the current inventories of the smaller more versatile ships.

In short, the Soviets will likely pursue shipping and shipbuilding policies designed to attain economic superiority while not losing sight of the political potentials and underlying military capabilities of this powerful arm of sea power. This approach suggests that some combination of military, economic, and political factors may provide the best explanation of the various aspects of Soviet merchant shipping. This basic question can be couched in terms of the relevant null hypotheses listed as follows:

1. H_o: The Soviet merchant Fleet Size is not explained by the combined military, economic, and political motivating factors.

2. H_o: Soviet merchant Ship Characteristics are not explainable by the combined military, economic, and political motivating factors.

3. H_o: The Soviet merchant <u>Fleet Mix</u> is not explainable by the combined military, economic, and political motivating factors.

The hypotheses listed in this section provide the basis on which the remainder of the study was conducted. The addition of similar hypotheses relating to the comparison of the USSR to other large maritime nations in general, and the USA in specific, add the depth of cross-national comparison to the study.

III. THE SCOPE OF THE STUDY AND CASE CONSTRUCTION

A. SPATIAL SCOPE

The unit of analysis of this research was the individual country. The study utilized 10 separate countries and five nation-entity units. The nation-entity units indicated below by an asterisk were "constructed" from either a conglomerate or a portion of a number of other actual country characteristics.

Nation-Entity	Abbreviation
Japan	JAPAN
United Kingdom	UK
USA (Both government and private ownership)	USA
*Effective U.S. Control (Foreign flag)	EUSC
*Parent U.S. (Foreign Flag)	PARUS
*USA (private ownership only)	PRIVUS
*US Military Usage (USA above plus EUSC)	USMIL
*US Economic Usage (Parent US plus Private US)	USECON
USSR	USSR
East Germany	GERMANY
Hungary	HUNGARY
Romania	ROMANIA
Bulgaria	BULGARI
Poland	POLAND
*Soviet Bloc (sum of all bloc countries)	BLOC
Czechoslovakia	CZECH

The countries were chosen with several criteria in mind. The country of greatest interest was the USSR and another major item of interest was the comparison of the USSR with the USA. The purpose of inclusion of the countries of Japan and the United Kingdom was to attempt to determine a more general predictive model for the large maritime nations of

the world. Such a predictive model could not be expected to apply to small maritime nations and is not intended to be of such a general application. The countries of Japan and the United Kingdom add balance to the study in that they represent two major maritime countries at different levels of development. Japan and the USSR have been termed the two great oceanic powers of the world [Polmar and Sayers, 1973]. Both have undergone rapid if not parallel expansion after World War II. The UK and USA on the other hand have relaxed their grasp on maritime supremacy since World War II.

The nation-entity units indicated above by an asterisk were created in order to enhance the comparability of the USSR and USA which espouse widely differing merchant shipping policies. The main policy difference is that the USA encourages the use of foreign flags of convenience by US corporations while the USSR strictly forbids the same practice. The policy of a nation in its merchant ship registration is what affects the desirability of registering a ship under that flag. The taxation, registration fees, requirements of construction design, location of construction, and labor source all come under the purview of the national registry. The result is that corporations of one nation will purchase and operate ships under foreign flags, so-called flags of convenience or necessity, while maintaining essential control within the first nation.

Consider the anomalous results of flags of convenience demonstrated in the table below.

	Thousands of Deadweight Tons 1971 (DWT)	International Seaborne Trade, Millions Tons	Ratio of Millions of Tons Trade/DWT
Panama	9,140	376	0.04
Liberia	60,992	5,352	0.08
USA	19,648	49,283	2.50

It can be seen from these figures that, although one would expect a high correlation between a nation's international seaborne trade and the size of its merchant force, for these countries, the factors appear to have little or no relationship. The reason is that the regulations of registry of the first two countries are very appealing, while those of the third country are much less so. Much of the tonnage in the registry of the nations of Panama and Liberia are under the effective control of the private corporations of other nations.

In the final analysis, many ships not under the U.S. flag are subordinate to U.S. concerns for economic gain and/or under U.S. control during times of national need.

Effective U.S. control, EUSC, is an official term for foreign flag vessels which have been deemed by the U.S. Navy Department to be under effective control of the U.S. regardless of ownership. Combination of this unit with the unit of USA (Government and Private Ownership) resulted in the new unit USMIL which includes virtually all that shipping that the U.S. government can call upon in emergency.

Parent U.S. (foreign flag) vessels are those vessels which belong to corporations whose ownership is controlled by U.S. citizens or whose charters are granted by the U.S. A combination of this with PRIVUS, privately owned U.S. flag shipping, represents that shipping which provides direct economic benefit to the U.S. and hence was termed USECON. The units USA, USMIL, USECON, have considerable overlap and are by no means mutually exclusive, but were intended to represent different manifestations of U.S. shipping.

The remaining constructed nation-entity unit is a sum of all Soviet Bloc countries. These countries are all members of COMECON, Council for Mutual Economic Assistance, and the dominance of the USSR in the economic planning and consequent realization of economic benefits of this alliance could be both determinant and resultant factors of BLOC shipping as a whole. Additionally, the prediction of the direction and magnitude of Soviet Bloc shipping by itself is of military significance, considering the tight Soviet military control over her contiguous satellites, and could be roughly compared to the USMIL category.

It should be noted that although the establishment of a broad data base is necessary in order to establish general theoretical results, significant results for the purpose of policy analysis can be obtained from a limited number or type of cases.

B. TEMPORAL SCOPE

The time period of this study was the years 1950 to 1973. This lengthy period represented a period of relative absence of major disturbances such as world wars or economic depressions which might have significantly biased the results. The data was drawn from each country for each year and in each case the data from the four previous years was included for the purpose of time lagging the data. A case then consisted of a country-year with a block of the data from the four previous years included. UK-1960 contains data drawn from the United Kingdom in 1960, 1959, 1958, 1957 and 1956, whereas UK-1968 contains 1968 data and that drawn from the four previous years. Each variable within a case is identified by a variable identifier and a time-lag prefix indicating the number of years that variable is lagged behind the nominal year. Case construction of this sort permitted the comparison of time-separated variables within each case both forwards and backwards without further manipulation of the file.

Appendix A contains a detailed breakdown of the case construction for the data used to create the initial SPSS file.

IV. VARIABLE SELECTION AND OPERATIONALIZATION

A. THE DEPENDENT VARIABLE: MERCHANT SHIPPING

The concepts chosen to represent the various aspects of merchant shipping are listed below.

DEPENDENT CONCEPT: INDICATORS

1. Overall Size of Fleet and Fleet Components

    a. Total deadweight tonnage (DWT) on a nation's registry
    b. Total numbers of ships on a nation's registry
    c. Freighter DWT
    d. Number of freighter ships
    e. Combination freighter and passenger ship DWT
    f. Numbers of combination freighter and passenger ships
    g. Bulk DWT
    h. Numbers of bulk ships
    i. Tanker DWT
    j. Number of tanker ships

2. Average Ships Characteristics

    a. Ship size (Average overall types) DWT
    b. Ship age (Average overall types) YRS
    c. Ship speed (Average overall types)KTS
    d. Ship draft (Average overall types)FT
    e. Freighter ship size (DWT)
    f. Freighter ship age (YRS)
    g. Freighter ship speed (KTS)
    h. Freighter ship draft (FT)
    i. Combination ship size (DWT)
    j. Combination ship age (YRS)
    k. Combination ship speed (KTS)
    l. Combination ship draft (FT)
    m. Bulk ship size (DWT)
    n. Bulk ship age (YRS)
    o. Bulk ship speed (KTS)
    p. Bulk ship draft (FT)
    q. Tanker size (DWT)
    r. Tanker age (YRS)
    s. Tanker speed (KTS)
    t. Tanker draft (FT)

3. Fleet Mix

    a. Freighter % (DWT) of total shipping
    b. Freighter % (numbers) of total shipping

c. Combination ship % (DWT) of total shipping
d. Combination ship % (numbers) of total shipping
e. Bulk ship % (DWT) of total shipping
f. Bulk ship % (numbers) of total shipping
g. Tanker % (DWT) of total shipping
h. Tanker % (numbers) of total shipping

1. Overall Size of Fleet and Fleet Components

In this study the aggregate size of the merchant shipping fleet was of a primary interest. Unlike displacement tonnage or "weight," deadweight tonnage is a measure of the carrying capacity of a ship, taking difference between the fully loaded and light conditions in tons of 2,240 pounds. This differs from gross registered tonnage (GRT) which is the other common measurement of the internal volume in 100's of cubic feet expressed in tons and measured in accordance with national tonnage regulations. The two measures vary proportionately for national vessels of the same construction and cargo but the proportionality differs among different types of ships and different nations. On the other hand, DWT remains a consistent measure of carrying capacity among all types of vessels, therefore, DWT allows a meaningful comparison between different ships of different nations.

Total capacity in terms of deadweight tonnage reflects the overall sealift potential readily convertible from economic to military use. The total number of ships connotes the flexibility of the fleet with military and economic ramifications and, of course, the political considerations of being able to "show the flag."

The fleet breakdown and source material for all of the variables are listed in Appendix B.

2. <u>Average Ship Characteristics</u>

The second major dependent concept, average ship characteristics was operationalized in terms of the average size, age, speed, and draft of the ships of each fleet.

These characteristics describe the general conditions of a merchant fleet and therein lies the value in their prediction. The average age of the ships of a fleet is a good measure of their reliability or obsolescence. The average size and draft are of interest in that many small ships represent a highly flexible force whereas fewer but larger ships generally represent a more economically efficient force. An increase in the size of a ship leads to a less than proportionate increase in costs. To operate efficiently, however, high load factors must be maintained. This varies for different types of ships and voyages. For example, large general-cargo vessels frequently must increase the number of ports of call, resulting in higher port costs. This provides one of the major constraints on the optimum size of such ships [Athay, 1971, p.20]. Likewise, port facilities and canals also place limits on ship size [Athay, 1971, p.21].

The constraints on optimum size of bulk carriers and tankers differs from freighters with the differing cargo type and length of voyages. On the average Soviet ships are smaller and draw less water than those of the other major maritime nations of the world. It has been hypothesized that the emphasis on smaller ships by the Soviets has been a

result of international political motivations. This thesis has intuitive appeal when the argument is presented that smaller ships can make developing country ports with greater ease. Testing of this hypothesis with empirical measures gives insight into the explanation of Soviet motivations as well as providing predictive models for the purpose of forecasting.

Within certain limits, an increase in the design speed of a ship results in a substitution of fuel costs for the costs of labor and capital. That is, putting to sea for less time (on a given voyage) saves more in labor and capital expenditures than the increased consumption of fuel [Athay, 1971, p.20]. That recently increased fuel prices have caused many shipping concerns to reduce the operational speed of their ships was not reflected in this study. Continuing fuel shortages could affect the reliability of the average speed and size prediction and this will be addressed in the concluding section.

The measures of age as an indicator of reliability and speed as an indicator of general capability both were both expected to exhibit strong relationships with military and economic measures.

3. Fleet Mix

The final major dependent concept is Fleet Mix, or the relative amount in terms of percentage of deadweight tonnage and numbers that each ship type provided of the whole. This concept of Fleet Mix is an added dimension of

the merchant fleet and gives insight into the emphasis of a national shipping policy.

The signficance of the Fleet Mix variable can be demonstrated by considering an example. The relatively high potential military value of a general purpose freighter when compared with specialized ships such as bulk carriers or tankers should be reflected in correspondingly high military indicators for the country which maintains a high percentage of freighters. The cross national comparison of these values and testing with regression analysis can provide predictive models for Fleet Mix values.

4. Technical Considerations of the Variables

The reliability of the data for all of the dependent variables is very high as the data was compiled from the U.S. Maritime Administration and U.S. Military Sealift Command documents (EUSC data only was drawn from the latter source). Average ship size and fleet mix variables represent a combination of other variables computed by the researcher from these sources. This breakdown is further defined in Appendix B.

Missing data was handled in two ways. If missing data occurred between years of present data, interpolated values replaced the missing values. If missing data appeared well outside the temporal range of recorded values, missing value indicators replaced these values and were deleted from consideration in statistical manipulations. For example, age, speed, and draft data was available only in the Maritime Administration's biennial reports dating

back to 1956. The odd year data was calculated by interpolation to create a complete annual series between 1956 and 1972. Conversely, the years 1950 through 1955 remained as missing data points for these variables.

The strict application of these two principles resulted in a highly reliable data set, but limited the application of certain statistical procedures to data sets with nearly complete records over the time span. This problem manifested itself with the nation-entity unit of USECON which contained dependent data over a range of seven years, with data from the years of 1967, 1968, and 1969 missing. Interpolation provided values for the three interim missing years, but an attempt to extrapolate beyond the total range of years clearly would be based on uncertain grounds. With only seven cases the powerful tool of regression analysis was denied.

B. THE INDEPENDENT VARIABLES

The independent variables selected represent the most important economic, political, and military factors which are likely to affect the merchant shipping of a nation.

The variables selected and the concepts which they represent appear below.

1. Military Domain
   a. Military Output
      (1) Military Expenditures ($) (N11)
      (2) Military Personnel (N12)

b. Military Effort

(1) Military Expenditures as a Percentage of GNP (N16)

(2) Military Personnel as a Percentage of Total Population (N17)

c. Military Potential

(1) Population (N13)

(2) The Product of Population and Energy Production (N30)

2. <u>The Economic Domain</u>

a. Economic Development, Science and Technology

(1) Energy Production (millions of metric tons of coal equivalent) (N07)

(2) Energy Consumption (N08)

(3) Energy Production per Capita (N32)

(4) Energy Consumption per Capita (N31)

(5) Energy Shortage - The Difference Between Production and Consumption (N29)

(6) Gross National Product (GNP)(N10)

(7) GNP per Capita (N27)

(8) Steel Consumption (N09)

b. International Trade

(1) Overall International Trade

(a) Imports ($)(N01)

(b) Exports ($) (N02)

(c) Balance of Trade ($) (N18)

(d) Total (imports plus exports) Trade ($) (N19)

(e) Total Trade as a Percentage of GNP (N36)

(f) Exports as a Percentage of GNP (N35)

(2) International Seaborne Transportation

(a) Imports (tons) (N03)

(b) Exports (tons) (N04)

(c) Total (tons) (N25)

(d) Balance of Seaborne Trade (tons) (N26)

(3) Less Developed Country (LDC) Trade Level

(a) Imports from LDC's ($) (N05)

(b) Exports to LDC's ($) (N06)

(c) Balance of Trade ($) (N20)

(d) Total Trade ($) (N21)

3. <u>The International Political Domain</u>

a. Economic Aid Effort

(1) Economic Aid to Other Countries ($) (N14)

(2) Economic Aid Given as a Percentage of GNP (N34)

b. Military Influence/Aid Effort

(1) Arms Exports (N15)

(2) Arms Exports as a Percentage of Total Exports (N28)

(3) Arms Exports as a Percentage of GNP (N33)

c. LDC Trade Interdependence

(1) LDC Exports as a Percentage of Total Exports (N24)

(2) LDC Imports as a Percentage of Total Imports (N23)

(3) LDC Total Trade as a Percentage of Total International Trade (N22)

(4) LDC Total Trade as a Percentage of GNP (N38)

(5) LDC Exports as a Percentage of GNP (N37)

In the process of choosing the independent variables many factors were considered. The validity of the entire study is based on the assumption of having utilized some of the key predictive or explanatory factors.

The works of R. J. Rummel, Dimensionality of Nations, and R. E. Athay, The Economics of Soviet Merchant-Shipping Policy, strongly influenced the construction of independent concepts and variables. The triad of military, economic, and political domains admittedly does not represent an exhaustive typology of predictive factors of merchant shipping. However, this classification clearly represents the key areas of motivation behind merchant shipping and the benefits which accrue from a successful merchant fleet [Athay, 1971, p.86].

Rummel's work, a landmark publication in the field of cross-national social statistics, presented the theoretical foundations and the operational definitions of many of the concepts utilized in this research.

1. Military Domain

The measures utilized to represent the military domain all have precedent in Rummel's work except that of military expenditure as a percentage of GNP.

2. The Economic Domain

In the economic domain the general concept of development and technology was operationalized separately from the field of international trade.

The measures used for economic development and technology all have precedence in Rummel's work with the exception

of Energy Shortage. Energy Shortage, the algebraic difference between Energy Consumption and Energy Production appears as a relevant factor in the economic motivation of at least certain portions of a nations merchant shipping, that is, the size, relative importance, and characteristics of the tanker fleet.

The concept of international trade as a subset of the economic domain was further divided into Overall Trade, Seaborne Trade, and Trade with Less Developed Countries (LDC). Although these divisions are mathematically redundant in that seaborne trade and LDC trade are both part of overall international trade, they represent categories that are conceptually independent. Additionally, the seaborne trade measure is in units of tons, whereas the overall and LDC trade is reported in dollars. The incomparability of the units of these measures provided additional justification for subdividing the trade concept. Unfortunately, the same incomparability of units prevented the computation of such potentially useful variables as seaborne trade as a percentage of total trade. Such a variable would represent the dependence of a nation on seaborne transportation with respect to its total international trade. The trade concepts and their various measures all have precedent in Rummel except for the LDC Trade concept, which the researcher inserted in order to test hypotheses specific to this study.

One additional concept in the economic realm which is potentially valuable in a study of this nature is

international financial status. In his study, The Economics of Soviet Merchant Shipping Policy, Robert Athay cites the Soviet balance of payments deficit and shrinking gold reserves as major economic motivations for the expansion of the Soviet Merchant Fleet in the 1950's and early 1960's [Athay, 1971, pp.53-85]. Unfortunately, the lack of reliable open-source data on some of the key aspects of Soviet international financial status on an annual basis precluded the use of that concept in this study. The Balance of Trade measure listed in the overall international trade section does describe one dimension of this concept but as it would very poorly represent the entire concept, it remains in the category of trade.

3. The International Political Domain

In the international political domain an effort was made to tap the national effort to extend or maintain the realm of economic and military influence. Additionally the concept of interdependence with the LDC's appears as a result as well as a determinant of national policy. Because of the highly varied operational definitions of the international political domain found in the literature, a detailed description of the variables chosen in this research is presented in the next few paragraphs.

The variables chosen to represent these factors contain no judgemental values and are all ratio scales with continuous variables ($, %). These types of variables lend

themselves to the complete types of mathematical manipulations without making further assumptions.

The concept of economic aid effort was operationalized in terms of total economic aid (U.S. dollars) to other countries and as a percentage of GNP.

Arms exports in U.S. dollars taken as a whole or as a percentage of total exports or GNP represent the military influence effort portion of international political domain. The dollar value of total arms exports, whether a portion of military aid programs or a non-grant trade transaction, best represents the military influence effort by circumventing the various problems involved in developing operational definitions of military aid. The data obtained from U.S. Arms Control and Disarmament Agency reports and SIPRI were used together to complete a 22 year series (1950-1971) of all countries. The data conflicts which appeared between the two sources were resolved by several steps. Initially, the older values were adjusted for inflation, the data points were then comparable in almost all cases. The remaining differences were resolved by averaging the data from the two sources, the difference being only a few percentage points at most. The reliability of this measure is more suspect than any other measure in the study.

The last conceptual subdivision of international political domain, LDC Trade Interdependence, was chosen to represent the importance or influence of interdependence of nations as a possible causal factor in the political realm

which could determine to some extent the nature and character of the merchant fleet. The indicators of this concept were the various aspects of LDC trade as a percentage of the corresponding type of international total trade and LDC trade as a percentage of GNP. These measures were computed from the previously documented trade and economic development measures. Although no precedent exists in the literature, the validity of these measures rests in the intuitive sense that the relative amount of trade which is conducted with LDC's represents a measure of the importance of that LDC trade. Conversely, but equally strong justification, such LDC trade is the result of concerted effort representing a political decision with international effects. The linkage of this concept to the character of a national merchant fleet lies in the international political realm.

4. Technical Considerations of the Variables

The reliability of these variables was established as very high by the nature of the data sources. The possible exception of the military influence measures was discussed in previous sections.

The measures were all on ratio scales (%, \$, tons, etc.) and were all continuous allowing statistical manipulations of the highest order.

Missing data was handled in the same manner as during the collection of the dependent data.

V. THE METHODOLOGY AND RESULTS

A. VARIABLE DESCRIPTION AND PREPARATION FOR ANALYSIS

After operationalizing the variables and gathering the data, the initial step of the analysis consisted of examining each measure individually. In addition to the values of the mean, mode and standard deviation, the values of skewness and kurtosis were examined to determine the nature of the measure's distribution. The techniques of bivariate correlation, factor analysis, and multiple regression analysis all rest upon the assumption that the variables exhibit a normal or nearly normal distribution [Blalock, 1960, p.276]. The primary reason for variables displaying non-normal distributions is the existance of outliers, in which cases the distributions may be skewed in one direction or the other or kurtosed (flattened) by larger numbers of outliers in each direction from the mean. A thorough discussion of variable transformation appears in the works of Rummel [1972, pp.174-176]. With the arbitrarily established criteria of a maximum kurtosis of ± 10.0 and a maximum skewness of ± 3.0, it was determined that of the 38 dependent and 38 independent variables only one would require transformation. D18, deadweight tonnage of bulk ships, was the only variable in excess of the criteria with a kurtosis of 23.7 and a skewness of 4.3.

On examination of the deciled histogram of D18 the proper transformation function was determined to be logarithmic

[Rummel, 1972, pp.174-177]. Post-transformation kurtosis and skewness values were well within established limits (-1.12, -.58 respectively). To determine if transformation had caused data distortion a correlation was made between the old measure and the new measure, now called D18X. A simple r of .58 significant to a .001 level indicated that no appreciable distortion had occurred.

The values of the mean, standard deviation, kurtosis, skewness, range, minimums and maximums are available on request from the thesis advisor. The values are listed for each variable with all countries and for each variable for each country.

B. BIVARIATE ANALYSIS

A correlational analysis was conducted on each of the dependent variables with each of the independent variables. Correlation means that the values of one variable are systematically related to the values of another. The correlation coefficient, commonly abbreviated r, represents the degree of association and varies from 0 to ± 1 with 0 indicating no relationship between variables and values approaching +1 (-1) indicating strong positive (negative) relationships.

Correlation analysis assumes that variables have normal distributions and represents only linear relationships. There is no inherent presumption in the process that either variable is the independent or the dependent measure;

therefore, no causal inference can be drawn from this statistic alone [Rai and Blydenburgh, 1972, p.176-177].

Correlation coefficients were obtained first using all of the countries and then by individual countries. The variables correlated first to the same-year variables, then to one year-lagged variables, to four year-lagged variables, lagging both the independent and the dependent variables. Figure V-1 pictorially represents the bivariate correlations examined.

The large number of values calculated (12,996 individual correlations or a 114 variable square matrix) precludes a full display here. The complete matrices are available from the thesis advisor.

The utilities of these simple correlation matrices are several fold. First, variables with very high correlations can be discovered and are valuable for conducting simple linear regression, thereby creating a linear equation which represents the mathematical relationship between two variables. Second, the correlation matrices provide for a sorting or screening process also applied to the selection of independent variables to represent a factor for the purpose of multiple regression analysis. When two or more independent variables were highly correlated to the same factor, the researcher chose the one which best predicted to the dependent variables.

The bivariate correlations further demonstrated the lag and lead relationships of the variables. The table which

THE BIVARIATE CORRELATIONS

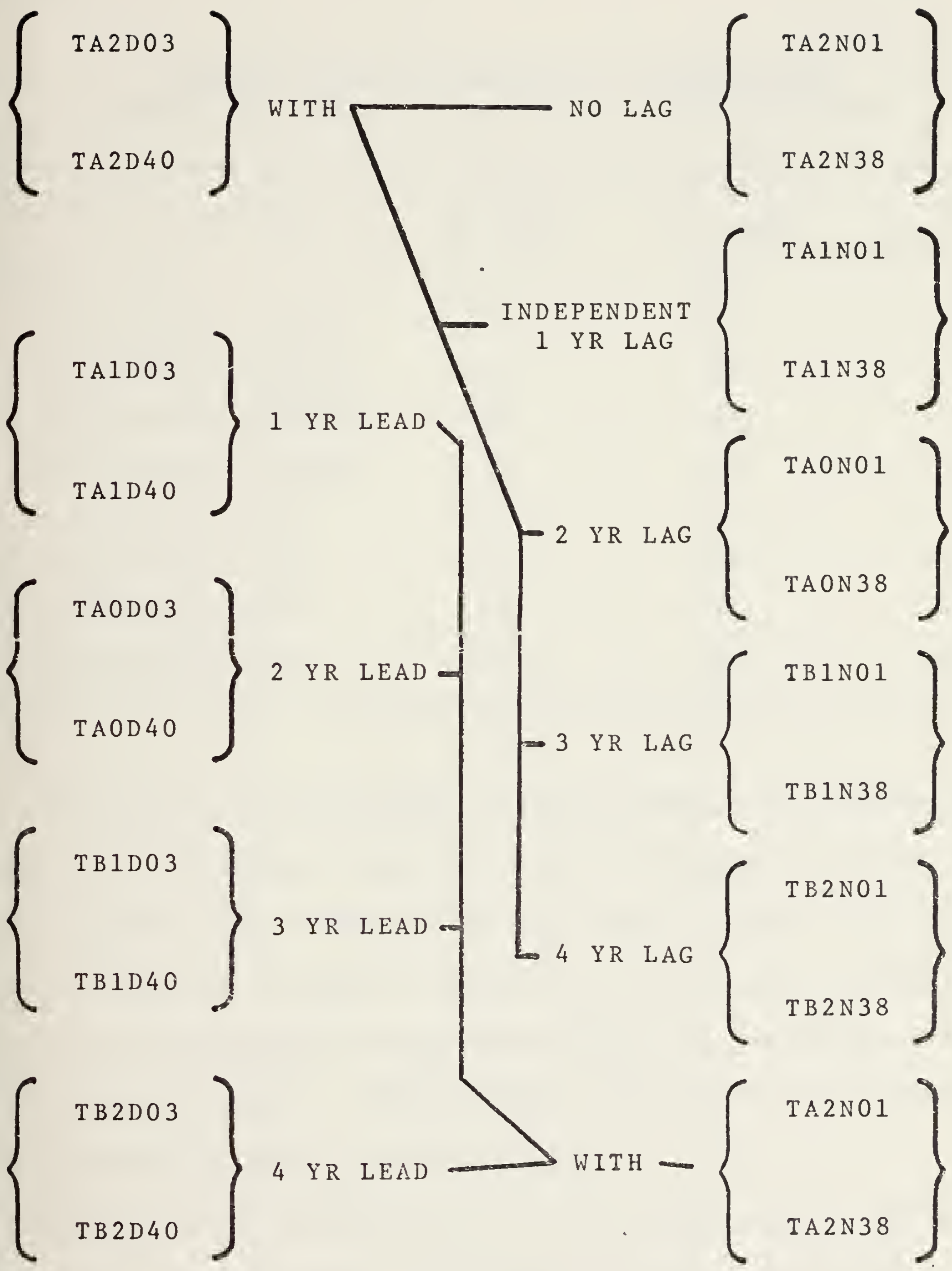


FIGURE V-1

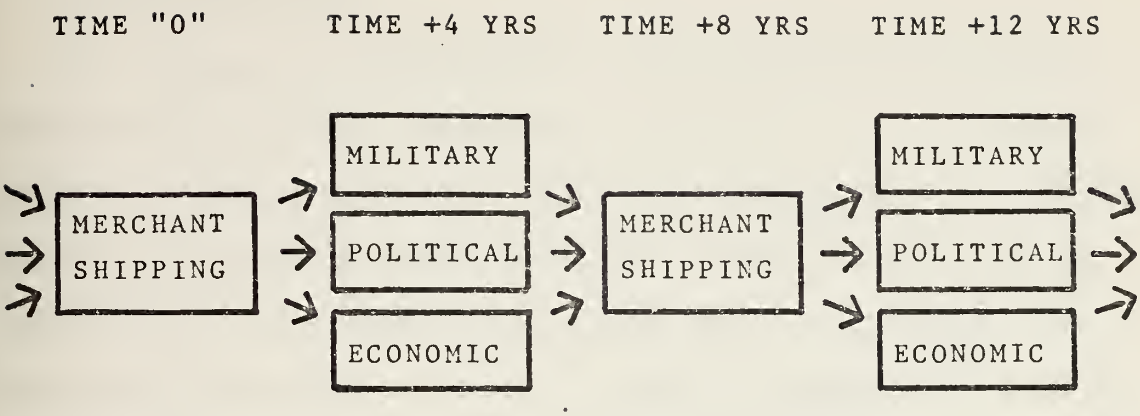
follows summarizes the level or correlation of the variables through various lags and leads (i.e., dependent variable lagged).

SUMMARY TABLE OF LEVELS OF CORRELATIONS
SIMPLE BIVARIATE CORRELATIONS (ALL COUNTRIES)

Time Lag (Lead) Yrs.	r=.75 or more	% r=.75 or more	r=.85 or more
"0" Same year	29	2%	0
1 Independent lagged	34	2%	3
2 Independent lagged	43	3%	4
3 Independent lagged	40	3%	5
4 Independent lagged	39	3%	6
(1) Independent led	57	4%	7
(2) Independent led	66	5%	13
(3) Independent led	51	4%	12
(4) Independent led	92	6%	20

Examining the lag portion of the table, an increasing level of correlation appeared as the independent variables were lagged. This observation was justification for further causal analysis. Again it should be noted that no definitive causal relationships can be established by bivariate correlation analysis alone. Later, other techniques will establish more plausible causal relationships.

Examining the lead portion of the table demonstrated that even higher levels of correlation were exhibited when the independent variables were led. This phenomena infers a possible feedback relationship which might be pictorially represented as follows.



FEEDBACK INTERRELATIONSHIPS

When bivariate correlations were conducted for each nation, both lag and lead levels of correlation were much higher. Whereas the all-nation percentage of high correlations (r greater than .75) never exceeded 6%, both the USA and USSR exhibited more than 50% of the correlation matrices with high levels of correlation for all lag and lead relationships examined. The inference is that there are inherent differences in the way different nations are motivated to pursue merchant shipping goals, that is, that there is a greater consistency within each nation in the way such goals are pursued. Such implications were reinforced by further analysis.

C. FACTOR ANALYSIS

The single most distinctive characteristic of factor analysis is its data reduction capability, ". . . factor-analytic techniques enable us to see whether some underlying pattern of relationships exists such that the data may be 'rearranged' or 'reduced' to a smaller set of factors or components that may be taken as source variables accounting for observed interrelations of the data," [Nie, et al, 1970, p.209]. Furthermore, factor analysis is based on the faith that these observed regularities are mainly the result of some underlying regularity in the data.

In addition to the data-reduction function, factor analysis will preclude committing the error of multicollinearity. To reiterate the discussion of this error in Section III, multicollinearity is the problem of utilizing two or more highly correlated independent variables in regression analysis. This "double counting" undermines the results of the process [Rai and Blydenburgh, 1973, p.232]. Since orthogonally rotated factors are essentially all statistically independent (i.e., uncorrelated), their use assures reliable results of the regression analysis.

1. The Factor Results

Initially, all cases together underwent factor analysis to determine underlying factors generally applicable to all of the major maritime nations studied. Table V-2 displays the results of this analysis.

In each factor the variables listed fall into groups subdivided by degree of correlation with the individual factor. For example, under factor I the top group variables all exhibited r greater than .90, the second group, N01, N02 etc., had r greater than .80. Following factor IV are the non-loading variables, those which failed to exhibit r greater than .6 with any given factor or which "loaded" (r greater than .6) with more than one factor.

This factor analysis afforded the researcher with considerable luxury in that there were many variables which loaded exceptionally high (r greater than .8) with each variable. The high loadings facilitated the attachment of an underlying concept to each of the factors. Examining each variable and its relative loading under a factor provided the evidence of the underlying concept which coalesced these variables.

2. Factor Names: Identification of the Underlying Concepts

Because of the nature of the computations in factor analysis, the first factor typically is a general factor, covering rather broad conceptual regions. Each additional factor represents increasingly more specific concepts until nearly all of the variance of entire data set is explained.

Factor I contains two distinctly discernable conceptual threads, level of trade and economic development. Variables N01, N02, N03, N05, N06, N19, N21, and N25 are all

TABLE V-1.

FACTORS - ALL NATIONS

	I	II	III	IV	Non-loading Variables
r=.9 or more	N03 N05(.94) N06 N21 N25	N35 N36	N22 N24		N04 N08 N14 N17 N20 N26 N32 N34
r=.8 or more	N01 N02 N19 N27 N29	N37(-.84) N38	N23(.84) N16	N33(.85)	
r=.7 or more	N10 N31	N09 N11 N12 N13		N28	
r=.6 or more		N07 N18 N30		N15	

Factor	Description	Representative Variable	Abbreviation
I	Level of trade and development	N05	TRADEVEL
II	Military Capability and Independence of trade	N37	MILCAP
III	LDC Importance	N23	NEEDLDC
IV	Arms Export Importance	N33	ARMSALE

Economic Domain	Military Domain	International Political Domain
Factor I	Factor II	Factors III and IV

trade variables. Variables N10 (GNP), N27 (GNP per capita), N29 (energy shortage), and N31 (energy consumption per capita), clearly represent a nation's economic development.

Factor II emerged as military capability because of the high positive correlations with the measures of military personnel and expenditures, (N11,N12), and the measures of heavy industrial capacity (N07, N09, N13, N30). The independence of trade was evidenced by very high negative correlation values of the various measures of trade as a percentage (N35, N36, N37, N38).

Factor III emerged as the LDC importance factor because of the high association of the measures of LDC trade as a proportion of total trade (N22, N23, N24).

Factor IV included only arms exports measures indicating the unique nature of this activity on the international scene.

From the purely inductive exercise of factor analysis 30 of the original 38 variables fell into four factors which describe the initially conceptualized military, economic, and international political realms. This empirical breakdown reinforced the conceptual genesis of the study and aided in the validation of the initial operational definitions.

3. Factor Representation and Index Construction

The prime value of the factor analysis in this study lies not in the above mentioned benefits but in the reduction of data. There are several methods of creating "new" indices

from factor analysis to represent the singular underlying concepts. The principle methods are: (1) the creation of factor scores from a factor coefficient matrix, (2) creation of a composite variable by simply adding the high loading variables of a given factor, and (3) the use of one high loading variable to represent each factor.[1]

To test the hypothesis that the three different indices were essentially the same, (i.e., highly correlated) the results of a factor analysis were used to create three new indices and these were correlated to determine their similarity. Because of the constraints of the machine program package the original factors developed were not useful for the creation of factor scores. A sample of 11 variables from the 38 were selected as representative of the four original factors with the addition of some non-loading variables. The factor analysis of these variables provided the following data.

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[1]The efficacy and validity of each method is the source of argument. In Hibb's work, Mass Political Violence, the three different methods are presented from his data set in order to determine what differences if any existed between the resultant composite indicators. The product of his research indicated that no significant difference existed between the various methods. The methodology utilized by Hibbs was replicated in this research [Hibbs, 1973, pp.11-17].

11 VARIABLE FACTOR SOLUTION

	Factor 1	Factor 2
N05	.89	.11
N37	.12	-.79
N23	.64	-.59
N32	.88	.39
N33	-.05	.56
N09	.56	.77
N10	.79	.53
N11	.54	.82
N17	-.21	-.55
N14	.91	.17
N30	.38	.85

Values above represent the correlation coefficient (r) of each variable to the indicated factor.

The two factors emerging represented generally (1) economic size, and (2) military capability and independence. The two variables chosen to represent each factor, N05 and N37, while not displaying the highest correlation with their respective factors, were in fact highly correlated and exhibited very low correlation with their "opposite" factor.

The correlation matrices below represent the results of the exercise.

Factor 1

	SCOR	N05	SUM
SCOR	1.00	.90	.97
N05	.90	1.00	.96
SUM	.97	.96	1.00

Factor 2

	SCOR	N37	SUM
SCOR	1.00	-.80	.88
N37	-.80	1.00	-.71
SUM	.88	-.71	1.00

SCOR: The factor score using all variables and factor score coefficients
SUM: The sum of the highest loading (r=.7) variables in the factor (underlined in the factor solution table).
N05: LDC exports (representative of factor one, economic size)
N37: LDC exports % of GNP (representative of factor two, military capability and independence)

The results clearly indicate that little if any advantage is to be gained by using one indexing method over another. The smallest r value in absolute terms was .71, significant to the .001 level, indicative of the very great similarity of the indices.

4. Validity Check of Factor Solution

Up to this point the face validity of the various factor solutions has not been established. To test the validity of the conceptual identification of these two factors, the five highest and five lowest scoring cases (utilizing factor scores) were examined. The results are displayed in Table V-2.

The results were examined to determine whether the empirically derived factors in fact held with the researcher's intuitive sense of reality. The five cases exhibiting the highest scores with factor I, economic size, were all USA, late years in the study. The smallest cases under factor I were the war-decimated eastern European countries and the USSR during the early post WW II years.

The military capability and independence factor, factor II, scored highest for the BLOC countries as a whole and the USSR in the latter years of the study. The intuitive appeal of these cases exhibiting overwhelming military capability and independence reinforced the conceptual predispositions on which the factor was defined.

The cases scoring lowest on factor II were the two island nations of the UK and Japan in the earliest years

TABLE V-2

FACTOR FACE VALIDITY CHECK

FACTOR I (ECONOMIC SIZE)		
Largest:	(1)	1973-USA
	(2)	1972-USA
	(3)	1971-USA
	(4)	1966-USA
	(5)	1970-USA
Smallest:	(1)	1954-USSR
	(2)	1953-USSR
	(3)	1953-BLOC
	(4)	1954-BLOC
	(5)	1952-USSR
FACTOR II (MILITARY CAPABILITY AND INDEPENDENCE)		
Largest:	(1)	1973-BLOC
	(2)	1972-BLOC
	(3)	1970-BLOC
	(4)	1973-USSR
	(5)	1971-BLOC
Smallest:	(1)	1951-JAPAN
	(2)	1950-JAPAN
	(3)	1950-UK
	(4)	1951-UK
	(5)	1952-JAPAN

examined. Their heavily populated small land areas in common qualify them for the lowest scores on an index of independence. These two countries both experienced the nearly complete destruction of their military-industrial bases during World War II which was evident for many subsequent years. This weakness of military capability was apparent in the low scores exhibited for factor II.

The testing of the factor scores by lowest and highest cases established the face validity of these factors. The high correlation of representative variables to these factors furthermore established their face validity and provides additional justification for the use of representative variables throughout the remainder of the analysis

5. Representative Variable Selection

The primary criterion for representative variable selection was that each correlate highly with its respective factor. As there were several variables in each factor which met this criterion, the researcher selected among those the variable which best correlated with the dependent variables. A perusal of the previously calculated bivariate correlation matrices provided the bases for these selections and the results are tabulated on the initial factor analysis table, Table V-1.

Although it was not the primary goal of this research to establish a general theory of large maritime-nation shipping, the discovery of such a generally applicable theory would have strengthened the predictive power of the results.

A general theory would transcend the temporal and national boundaries of the research, thus providing a model which one could apply, within a certain level of confidence, to any large maritime nation over any time-span.[2]

In order to test the general applicability of the factor analysis the researcher conducted a cross-national and temporal stability check. The time-period of the study was divided into three shorter time-spans of 1950 to 1958, 1959 to 1965, and 1966 to 1973. The results of the three factor analyses demonstrated the lack of temporal stability of the factors. Through the first two time periods the trade and development factor was consistent with the overall results, although variable loadings on the factor was considerably weaker in the shorter time-spans. This factor failed to remain consistent in the last time-span (1966-1973) as the variables loaded on other factors. All other factors failed to be reproduced in any of the sub-divided analyses. A full discussion of these phenomena would be of interest but is clearly beyond the scope of this research.

The cross-national stability check provided a test of the general applicability of the factor analysis and additionally was expected to supply empirically derived factors for use in individual country regression analyses.

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[2]A thorough discussion of the theoretical foundations of concept stability as applicable to general theory formulation appears in the article, "Concept and Measurement Stability in the Study of Conflict Behavior Within Nations," by Leo A. Hazlewood [Comparative Political Studies, July 1973].

The factor analyses by individual nation demonstrated that the factor solution for individual nations did not correspond to the more general results. In fact, the data of individual nations were so monotonic that the procedures of factor analysis hardly applied. No usable factors could be derived and in later applications of variables to regression analyses each combination of variables was tested individually for multicollinearity.

In conclusion, caution is advised in utilizing the results of this factor analysis for testing a general theory. However, for the purposes of policy research dealing with specific questions, the use of variables chosen to represent conceptual elements of a model is entirely justified. Only the application of the results outside of the specific problem area of study will lack a theoretical basis. If one takes care that the variables are chosen on sound bases and that such errors as multicollinearity or mathematical redundancy are avoided, meaningful statistical results will occur.

D. REGRESSION ANALYSIS

1. A Brief Discussion of the Theory and Techniques of Regression Analysis

The primary objective of this research was the developement of a set of predictive equations of Soviet merchant shipping. The major technique of this effort was multiple linear regression analysis. This section briefly describes the mechanism of regression analysis and demonstrates its application to this research using the general empirical factors developed in factor analysis.

The result of a regression analysis is actually a descriptive equation consisting of a number of independent variables, properly weighted with b coefficients determined by a least squares fit, which produce an estimate of the dependent variable.

If the model is to become truly predictive, one must lag the independent variables behind the dependent variables. Having accomplished lagging, the assumption that this is a predictive model is only strictly applicable within the time-frame of the study, lest one commit the longitudinal fallacy [Gurr, 1972, pp.33-35]. However, since the major purpose of this research is to create a model for policy utilization, one can use the predictive model outside the temporal scope of the statistical analysis (i.e., predict into the future) as long as the theoretical weaknesses are kept in mind.

a. The Measures of the Quality of a Regression Equation

There are three measures of the quality of a regression equation: (1) a measure of the distribution of the observations about the estimated points of the regression plane, (2) the percentage of variance explained by the regression, and (3) a measure of whether the b's, when considered individually or together, differ significantly from zero.

Before continuing let us consider a sample equation, the result of a regression analysis in this study.

SAMPLE REGRESSION EQUATION - ALL NATIONS

(Independent variables lagged two years)

$$\text{TOTAL DWT}(t) = 3.44\ \text{TRADEVEL}(t-2) + 313\ \text{NEEDLDC}(t-2) + 2.64\ \text{ARMSALE}(t-2) + 18.91\ \text{MILCAP}(t-2) - 10363.08$$

or for standardized variables:

$$Z_{\text{TOTAL DWT}(t)} = .65Z_{\text{TRADEVEL}(t-2)} + .32Z_{\text{NEEDLDC}(t-2)} + .03Z_{\text{ARMSALE}(t-2)} + .02Z_{\text{MILCAP}(t-2)}$$

Measures of Quality of the Equation

R^2	= .74	Equation F	= 44.59
S.E.	= 7776.71	Significance Level	= .01

The Equation in Tabular Format

Independent Variable	b	S.E. of b	beta	F
TRADEVEL	3.44	0.30	.65	63.86
NEEDLDC	313.00	90.91	.32	11.85
ARMSALE	2.64	5.96	.03	0.20
MILCAP	18.91	66.69	.02	0.08
Constant	-10363.08	-	-	-

The first measure of quality is the standard error of estimate, hereafter called S.E. This measure is the sample standard deviation of the observed dependent data points about the results of the regression equation, that is, about the expected values of the dependent variable. The S.E. corresponds to the sample standard deviation of the dependent variable and the quality of the equation can be compared on that basis.

In this case the S.E. was about half the value of the standard deviation of the dependent variable. Although one cannot say that this estimate is "twice" as good as selecting the mean value of the variable, it is clearly a better choice.

Considering the second measure of the quality of a regression equation, the value R^2, <u>coefficient of multiple determination</u>, provides the percentage of explained variance of the dependent variable. In this case, $R^2 = .74$, that is, 74% of the variance of merchant shipping total DWT of a nation was explained by the equation; 26% remained unexplained. This measure of R^2 is normally considered the key criterion for determining the successful choice and application of variables. The unexplained variance could theoretically be explained by the inclusion of some other unknown variables (perhaps rat population in a nation's seaports). The selection of a minimum criterion of R^2 for hypothesis testing is arbitrary. For this research, minimum R^2 for rejection of the null hypothesis was .50, a commonly accepted standard.

The third measure of quality of the regression equation is whether the b coefficients individually and cumulatively differ significantly from zero. To examine each variable individually, a t-test is customarily applied, or for more than 30 cases a Normal table may be used. t is calculated as a ratio of b to the S.E. of b. Consider an example from the sample regression equation:

$$t_{TRADEVEL} = \frac{3.44\ (b_{TRADEVEL})}{0.30\ (S.E._{TRADEVEL})} = 11.46$$

Consulting a t distribution table provided the information that TRADEVEL indeed differed from zero at a significance level exceeding .0005. Using another example from the sample equation the following results appeared.

$$t_{MILCAP} = \frac{18.91}{66.69} = .28$$

Significance level = .351

Thus MILCAP did not significantly add to the equation (commonly accepted criterion, significance level of .05 or less). In other, perhaps more descriptive terms, the researcher could not confidently predict the sign of the coefficient of MILCAP.

Two other guides for the evaluation of individual variables are the beta coefficient and the F statistic of the individual variable. The beta coefficient is the transformation of the b coefficient to make it suitable for use with standardized variable values (Z values). Since the beta coefficients or beta weights are all utilized with standardized variables, their relative weightings can be determined by visual observation. Referring to the beta weights in the sample equation, variables TRADEVEL and NEEDLDC represented large additions to the equation, whereas ARMSALE and MILCAP added very little, nearly zero, to the equation. The F statistic of each variable can be taken to a F distribution table, entered with the proper degrees of

freedom, and a significance level derived. In this case TRADEVEL and NEEDLDC were both significant beyond the .01 level; neither ARMSALE nor MILCAP met the minimum criterion of .05 significance level. All of these measures of the quality of individual values indicated that the measures ARMSALE and MILCAP could have been deleted from this equation. Unless there were overriding conceptual or theoretical justifications the variables probably would be deleted. However, even if the variables were retained, their effect on the overall equation would be small, that is, according to their relative weightings. In other words, having knowledge of ARMSALE (arms export importance) and MILCAP (military capability and independence) will not aid the policy analyst in predicting DWT Total. The one condition under which the variables would require deletion is that instance in which their inclusion jeopardizes the statistical significance of the equation as a whole. This introduces the last evaluative procedure.

The significance test of the regression is another F ratio, testing the null hypothesis that all of the contributions of the independent variables do not represent a statistically significant (.05 level) relationship with the dependent variable [Rai & Blydenburgh, 1973, p. 231]. Entering the F distribution table with the values of F and the proper degrees of freedom one can determine the significance level of the equation. The F ratio of the sample equation was significant beyond the .01 level, indicating

an acceptance of the equation and a rejection of the corresponding null hypothesis.

A random selection of a case will demonstrate the use of the sample equation.

UK-1969	Raw Score	Mean	Std.Dev.
TA2DO3(actual) DWT Total	33133.00	12527	14760
TAON05 -TRADEVEL	3940.00	3788	2801
TAON23 -NEEDLDC	26.00	28.69	15.27
TAON33 -ARMSALE	88.18	186.35	179.77
TAON37 -MILCAP	29.00	19.93	16.82

Equation I, b coefficients

$$\text{Expected DWT Total} = 3.44\ (3940) + 313\ (26) + 2.64\ (88.18) + 18.91\ (29) - 10363.08$$

$$= 13553.6 + 8138 + 232.8\ 548.39 - 10363.08$$

$$= 12110$$

$$\text{Residual} = 21023$$

Equation II, beta weights

$$z_{\text{DWT TOTAL}} = .65\ \frac{(3940 - 3788)}{2801} + .32\ \frac{(26 - 28.69)}{15.27} + .03\ \frac{(88.18 - 186.35)}{179.77} + .02\ \frac{(29 - 19.93)}{16.82}$$

$$= .0353 + (-.0564) + (-.0164) + .0108$$

$$= -.0267 = \frac{(\text{Expected DWT TOTAL} - 12527)}{14760}$$

Expected DWT TOTAL = 12133 Residual = 21000

b. Analysis of the Residuals

The results from entering the regression equations with the appropriate values are demonstrated in the preceeding table. The regression equations produced an expected value of DWT TOTAL which in this case differed markedly from the actual value. This difference is called

the residual and examinations of the residuals can be the subject of an entire research project. An in-depth analysis of residuals is too detailed to be included in this study, but a few comments utilizing the selected example will be of value and aid the observer in evaluating further regression analyses.

The residual in the case of Equation I of 21023 DWT can be interpreted by comparison with the standard error of the equation, 7776.71. A ratio of the residual to S.E. provides effectively the number of standard errors the actual value differs from the expected value, in this case 2.70. This value, converted by means of a normal or t distribution, presents the residual in terms of probability of occurrence, assuming a random normal distribution about the expected value of the equation. The corresponding probability is .007, a very very slim chance of this occurring due to random errors. Such results infer that there was something about the case UK-1969 that differed significantly from the general model, thereby isolating the case for further study by the analyst.

Another item of interest is the different results of the b and beta equations. Although it has been hypothesized that the standardized coefficients impose an artificiality on the data, the effective use of betas does improve the predictive capability of the equation [Rai and Blydenburch, 1973, p. 227]. Note that for UK-1969 the value determined with the use of betas (Equation II) is closer to

the actual value than the results of Equation I (b coefficients). This is apparent because of the increased effect of weighting the variables according to relative importance.

c. Prediction Using the Regression Equation

One final application of the sample regression equation is the predictive usage. Consider the time-lagged nature of the independent variables in the equation. The dependent variable is two years ahead of the independent variables. For the case UK-1969 the variable TA2D03 is a 1969 data point and the independent variables are 1967 data points. The logical extension of this equation to use 1974 independent data points to predict to 1976 dependent estimates. This procedure threatens a longitudinal fallacy but since the major goal of this study is a predictive methodology, not a general theory, it was necessary to make the reasonable assumption of continuity in order to extend the application beyond the temporal limits of the data set. That is, the assumption was stated that the environment in which the analysis was conducted will remain essentially the same over the period of the prediction.

For purposes of illustrating the predictive utility of regression equations, the three-year lag equation for freighter size is displayed in Table V-3. The mythical case USSR-1974 (mythical because end of 1974 USSR data was not available at the time of this study) was used to predict the USSR freighter size at the end of 1974 using independent data points from 1971. The 1971 raw values were entered

TABLE V-3

FREIGHTER SIZE GENERAL (ALL-NATIONS)
PREDICTIVE EQUATION (INDEPENDENT VARIABLES LAGGED THREE YEARS)

CASE: USSR - (1974)

Variable Description	Raw Data Point	Mean	Standard Deviation	Equation Values: b Coef.	Equation Values: Beta Coef.
Freighter Size	Unknown (1974)	7282.15	3051.77	---	---
TRADEVEL (1971)	1580	3788	2801	.89104	.732
NEEDLDC (1971)	13	28.69	15.27	64.637	.327
ARMSALE (1971)	450.3	186.35	179.77	2.107	.124
MILCAP (1971)	10.3	19.93	16.82	13.277	.075
Constant	---	---		1876.356	---

EQUATION MEASURES OF QUALITY:

R^2 = .9263 F = 198

S.E. = 857.7541 S = .001

RESULTS:

B Coefficient Estimate: 5210 DWT

Beta Coefficient Estimate: 4920 DWT

Freighter Size Mean Value: 7282 DWT

USSR 1969 Freighter Size: 6800 DWT

USSR 1970 Freighter Size: 6210 DWT

USSR 1971 Freighter Size: 6323 DWT

USSR 1972 Freighter Size: 5980 DWT

USSR 1973 Freighter Size: 6003 DWT

into the equation using b coefficients and standardized 1971 data points were entered into the beta-coefficient equation. The results are tabulated and graphically displayed at the bottom of Table V-3. The resultant 1974 estimates may be visually compared with the 1969 through 1973 freighter size values and the freighter size mean value for all nations which is another method of estimating USSR freighter size.

When considering the value of this estimate one must recall that this regression model was established for <u>all</u> major maritime nations. Later equations developed using only USSR data provided even better (higher R^2) estimates, but first a discussion of the results of regression analyses using all cases will be presented.

2. <u>Regression Analysis Results Using Inductively Derived Factors - All Cases</u>

Regression analysis were conducted on all 38 of the dependent variables using all cases with the factors developed from the factor analysis. The equations were computed first with all data from the same year, then with independent factors lagged as a group progressively from one to four years. The results of the analyses generally improved with greater lags. The table below displays this occurrence.

	Number of Equations with R^2 Less Than .5	Number of Equations with R^2 Greater Than .9
No Lag	16	0
Lag 1 year	14	2
Lag 2 years	13	2
Lag 3 years	11	2
Lag 4 years	10	2

The displayed trends strengthened the assumption of causal relationships between the independent and the dependent variables.

In a further effort to improve the predictability of the general equations the factors were independently time varied. Since the researcher had not developed a model describing a sequential relationship between the various predictive factors, the selection of the differential time laggings resulted from a search through the dependent-independent bivariate correlation matrix. Each selection was based on the lag relationship resulting in the highest correlation for each factor with each dependent variable. Twenty-six of the 36 original equations failed to exhibit R^2 values greater than .75 and these were subjected to the new technique. Of the 26 regressions computed 10 resulted in improved R^2 values, a complete listing of the regression equations is available from the thesis advisor. Included in this listing is a tabulation of the best (highest R^2) equation for each dependent variable.

For the reader's perusal a few of the regression equation results are displayed in Table V-4. Beta coefficients were used so that the observer may compare variable weightings or relative importance in the different equations. The equations were sampled to include indicators of each facet of merchant shipping: <u>Fleet Size</u>, <u>Ship Characteristics</u>, and <u>Fleet Mix</u>. Successful equations (R^2 greater than .50) as well as unsuccessful equations were included.

TABLE V-4

REGRESSION RESULTS WITH INDUCTIVE FACTORS
(ALL CASES) BETA VALUES

	TRADEVEL N05	MILCAP N23	ARMSALE N33	NEEDLDC N37	R^2	BEST LAG (YEARS)
Fleet Size:						
Total DWT D03	.65	.32	.03	.02	.74	2
No. of Bulk Ships D19	.31	-.31	.26	.68	.37	Varied
Ship Characteristics:						
Ave. Draft D07	.75	.22	.03	.10	.80	3
Combination Ship Draft D11	.89	-.18	.16	.17	.64	4
Freighter Age D15	.52	-.56	-.42	-.52	.69	4
Bulk Ship Draft D22	.81	.05	-.35	-.08	.81	0
Tanker Draft D27	.77	-.01	-.25	.38	.78	Varied
Freighter Size D30	.75	.34	.12	.08	.96	3
Fleet Mix:						
Comb. No. % of Total D34	.14	-.16	-.24	-.36	.20	Varied
Tanker DWT % of Total D39	.80	-.29	.30	.40	.63	0

The ten dependent variables selected above represent a cross section of the 38 dependent variables investigated in the research.

In order to test the general equations for feedback relationships the lagged factors were reversed to provide lead equations. That is, the dependent variables were individually placed temporally behind the independent factors. The results of this effort indicated that there was indeed a strong feedback relationship in effect for most of the dependent variables. Twenty-eight of the 38 lead equations were significant (R^2 greater than .50), and of these, 20 actually showed a predictability greater than the lag equations. Some lead equations showed little or no relationship where a strong lag relationship had been shown to exist. The table which follows displays some of the more pronounced variations.

Variable	Best (Highest R^2) Lag Equation	Best (Highest R^2) Lead Equation
Overall Ship Age	.63	.81
Overall Ship Speed	.57	.75
Combination Ship Age	.71	.95
Freighter Age	.69	.91
Tanker Age	.75	.64
Tanker Draft	.74	.91
Tanker Size	.64	.75
Freighter (DWT) % of Total	.60	.44

It can be concluded that feedback relations do exist to a significance level of .05 for most of the dependent variables. The complete list of these variables and their equations are available on request.

3. <u>Regression Results Using Inductively Derived Factors - Cases USA, USSR</u>

At this point in the research regression analyses were conducted for each country individually using the inductively derived factors. For purposes of brevity, from this point forward in the analysis only the USSR and USA individual case analyses appear in this report. The results for other countries studied is available on request.

As earlier reported, factor analyses by individual country failed to produce satisfactory results. For this stage of the analysis the general inductively derived factors were used as long as sufficient independence or lack of multicollinearity could be established. The results of the representative analyses are summarized in Table V-5. The blank entries for beta coefficients occurred either because multicollinearity precluded inclusion of the additional variables or because the addition of such variables failed to be of significance to the overall equation. The correlation matrices at the bottom of the table display the basis on which multicollinearity was determined.

The regression results for each country were higher than those for all countries together, inferring a greater consistency within each country than had been observed for the aggregate. Note that of the tabulated equations only one of the twenty failed to meet the minimum criterion (R^2 greater than .50) for rejection of the corresponding null hypothesis. That equation was D07 (average draft of all vessels) for the USSR. Of all 38 USSR equations only D07,

TABLE V-5

REGRESSION RESULTS WITH INDUCTIVELY DERIVED FACTORS
US/USSR

	USA						USSR					
	N05	N23	N33	N37	R^2	LAG	N05	N23	N33	N37	R^2	LAG
Fleet Size												
D03	-	-	-.96	-	.96	4	.95	-	-	-	.97	1
D19	-.995	-	-	-.59	.71	Var	-	-	.50	-	.81	1
Ship Char												
D07	.75	-.62	-	.39	.88	4	-	1.45	-	-	.42	3
D11	-	-.43	-	-.41	.60	4	-	.32	-	-	.92	3
D15	.41	-.87	-	.20	.97	4	-.65	-	-	-	.97	3
D22	-	-	.46	-.36	.87	3	-	.67	-	-	.81	3
D27	.27	-.61	-	-	.91	2	.48	-	-	-	.89	1
D30	1.28	.55	-	-	.93	2	-	-	-	.62	.83	2
Fleet Mix												
D34	.84	-	-.32	.27	.90	Var	-	-	-	-1.26	.93	3
D39	.82	-	-	-.15	.96	1	-	-	-	-1.26	.93	3

USA

	N05	N23	N33	N37
N05	1.0	-.78	.82	-.46
N23	-.78	1.0	-.91	.69
N33	.82	-.91	1.0	.95
N37	-.46	.69	.95	1.0

USSR

	N05	N23	N33	N37
N05	1.0	.81	.70	.94
N23	.81	1.0	.79	.85
N33	.70	.79	1.0	.98
N37	.94	.85	.98	1.0

D20 (average age of bulk ships) and D37 (bulk ship DWT % of total) failed to meet this criterion whereas for the previously displayed all-ntion equations 10 of the 38 failed to be predictive. Thus, having performed regression analysis with lagged military, economic, and political indicators, the null hypotheses stated at the end of Section III regarding the combined effect of these factors on the various manifestations of Soviet Merchant Shipping were rejected.

In the case of the USA only one variable, D17 (freighter average draft), failed to be predictive and corresponding null hypotheses for the USA could be rejected on this same basis.

Had the inductively derived factors for all nations held with individual nations, a great deal could be stated about the relative weightings of the different factors in the successful equations. Since there were problems of multicollinearity, especially in the case of the USSR, in many equations only one of the independent factors could be utilized, effectively creating simple linear regression results.

One can make rough comparisons, such as total fleet size (D03) of the USSR is best predicted by the trade and development factor (N05), while the number of bulk ships (D19) is best predicted by a political indicator, arms export importance (N33). However, the validity of such a comparison is suspect, considering the high correlation of these factors within individual countries. The attribution of these all-nation factors to the individual nations in a

strict sense represents an ecological fallacy, in this case attributing to an individual the characteristics of the group.

A better method of comparing the relative importance to merchant shipping of economic, military, and political motivating factors is to create causal models. An evaluation of the effectiveness of these models provide a better measure of the relative value of the various predictive factors. The development and testing of causal models is the subject of the next section.

E. THE CAUSAL MODELS FOR MERCHANT SHIPPING

A model in its purely abstract form is ". . . a means by which critical aspects of familiar processes are logically related," [Rai and Blydenburch, 1973, p2]. The creation of a model is basically a deductive process by which the creator expects to explain a phenomena of interest. In this section the researcher created models of plausible economic, military, and political causes or motivating factors of Soviet Merchant Shipping.

From previous analysis it can be deduced that the factor breakdown of the total data set (i.e., all major maritime nations) reinforced the predispositions of the researcher in collecting and categorizing his initial information. Additionally, while the factor analysis was useful to some extent in determining the relative importance of the various factors for all nations, that utility broke down when applied to individual nations. The causal models thus served on the

one hand to provide competitive models by which the researcher could conclude the relative importance of different motivating factors.

On the other hand, each model individually was intended to present a viable method of explaining merchant shipping, notwithstanding other contributing factors. No assumption was stated concerning the exhaustive character or mutual exclusiveness of the models. With these comments in mind, recall the general hypothesis listed near the end of the historical analysis, Section II. These null hypotheses stated that the various manifestations of Soviet Merchant shipping cannot be explained by the military, economic, and political motivating factors taken individually. The models created were individually tested to determine the acceptance or rejection of these hypotheses.

In attempting to derive causal models of merchant shipping, a search of the literature was largely unfruitful with one notable exception. In a paper submitted for the American Political Science Association meeting of 1969, Nazli Choucri and Robert C. North presented various peace-system models using a nation's merchant marine as a contributing variable (operationalized by gross registered tons) [Russet, 1972, pp.239-274]. Although their interest was mainly in alternative paths to military preparedness, the models provided various plausible linkages to merchant shipping, some of which are replicated in part in this study.

It is worthwhile to note that these models were constructed before the initial analysis; the variables chosen to operationalize the concepts were therefore largely deductively determined, not the result of statistical factor analysis.

The models are diagrammatically presented on the following pages. Note that the models demonstrate a variation of the previously utilized factors defined in the factor analysis. In the military domain the emphasis is on military capability. In the international political domain, the emphasis is on international influence potential. In the economic domain, international economy activity is emphasized. In the following sections each model is explained and the results of the causal analyses are reported.

1. The Military Model: Model I

The two initial concepts of Model I were operationalized according to the same logic and pattern of precedence used in the operational definitions at the beginning of the research. Also, the results of the initial factor analysis were used in some cases where the factor definition fit the concept. Where no common indicator was found, a variable representative of the concept was chosen on the basis of the researcher's deductive insight from previous research.

The primary statistical process used in this section was regression analysis. The lagging of the independent concepts (in this case economic development and military effort four years, and military capability, two years)

MODEL I
THE MILITARY CAPABILITY MODEL

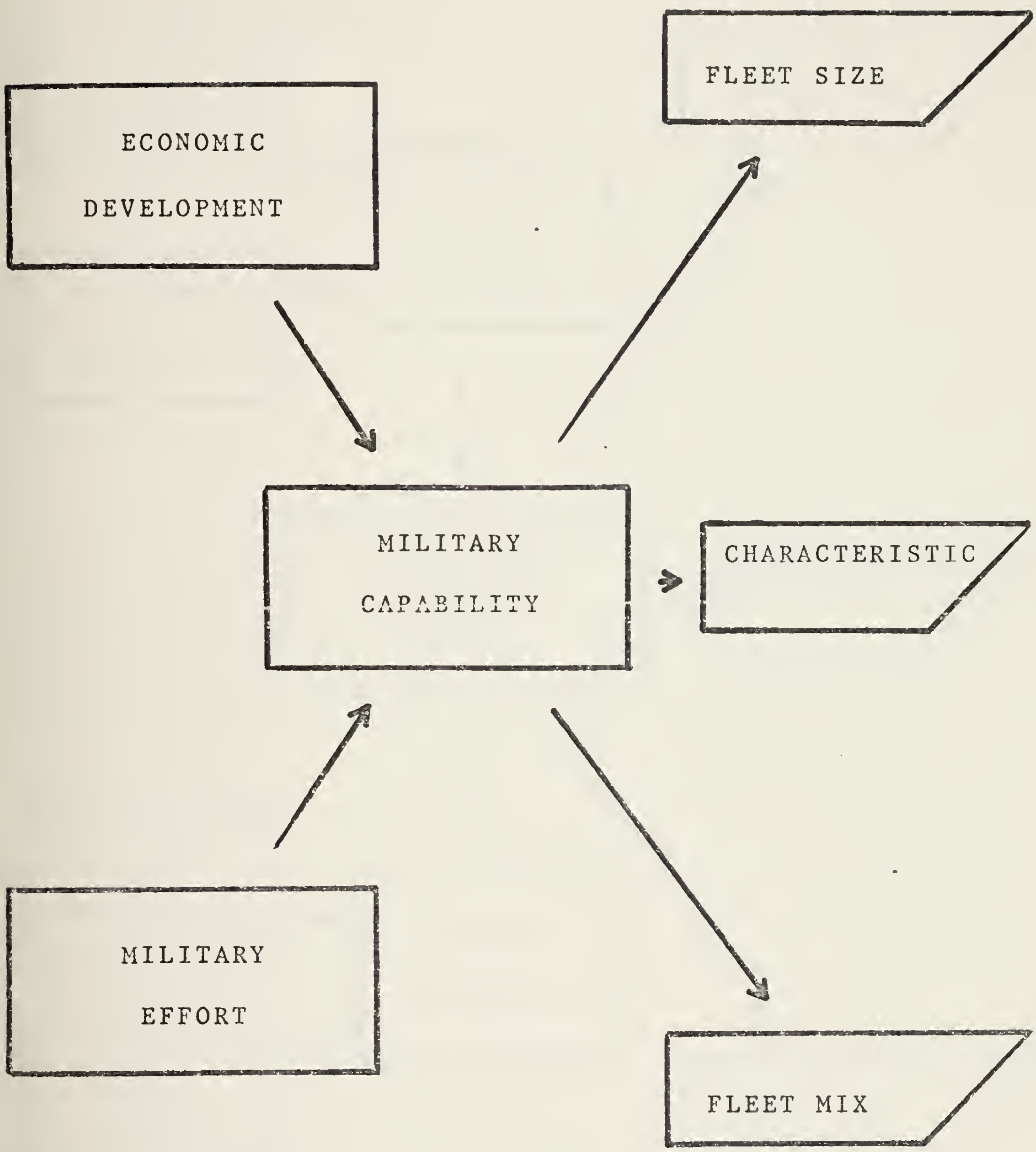

FIGURE V-2

MODEL II

THE INTERNATIONAL POLITICAL INFLUENCE MODEL

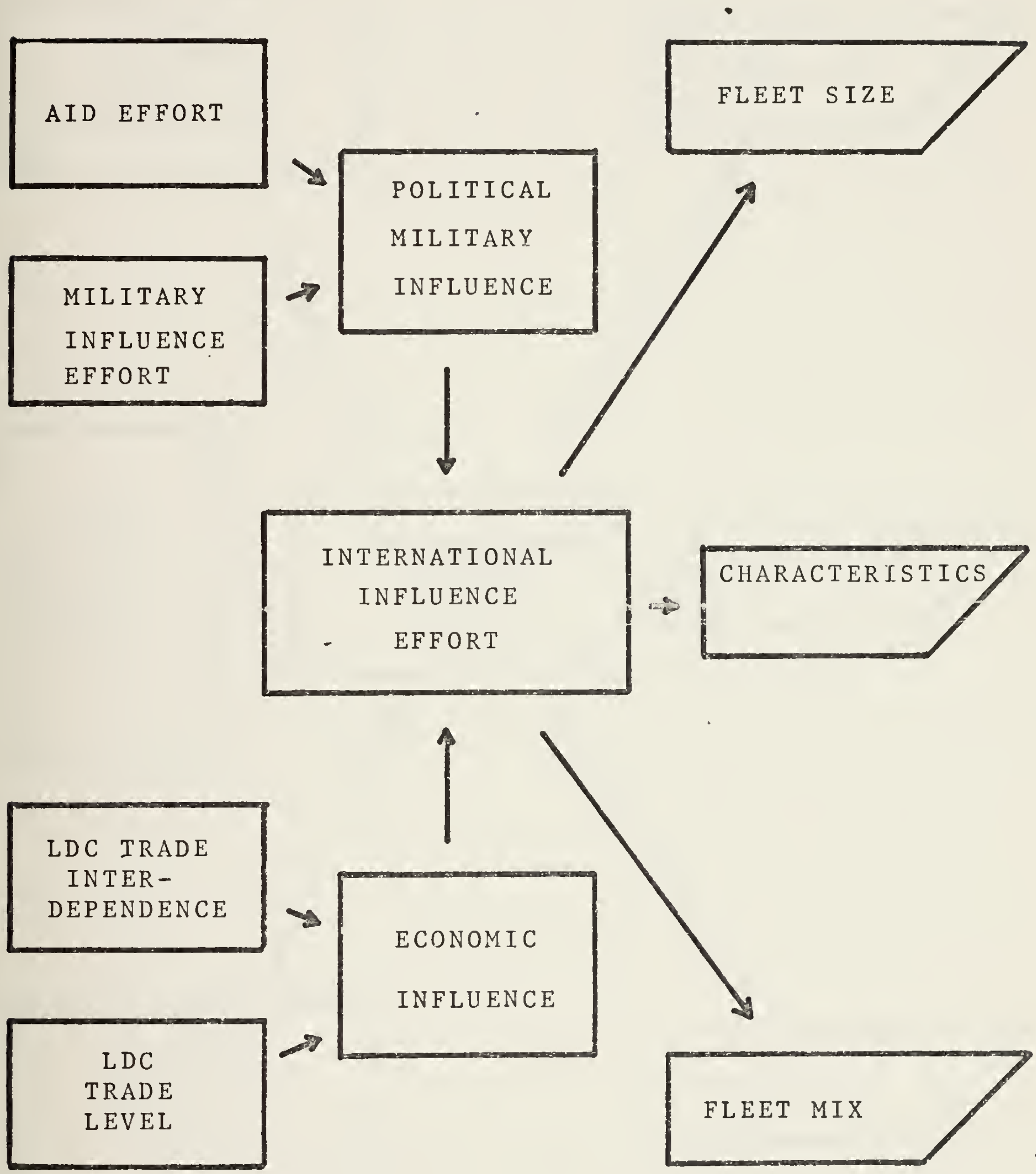

FIGURE V-3

MODEL III

THE INTERNATIONAL ECONOMIC ACTIVITY MODEL

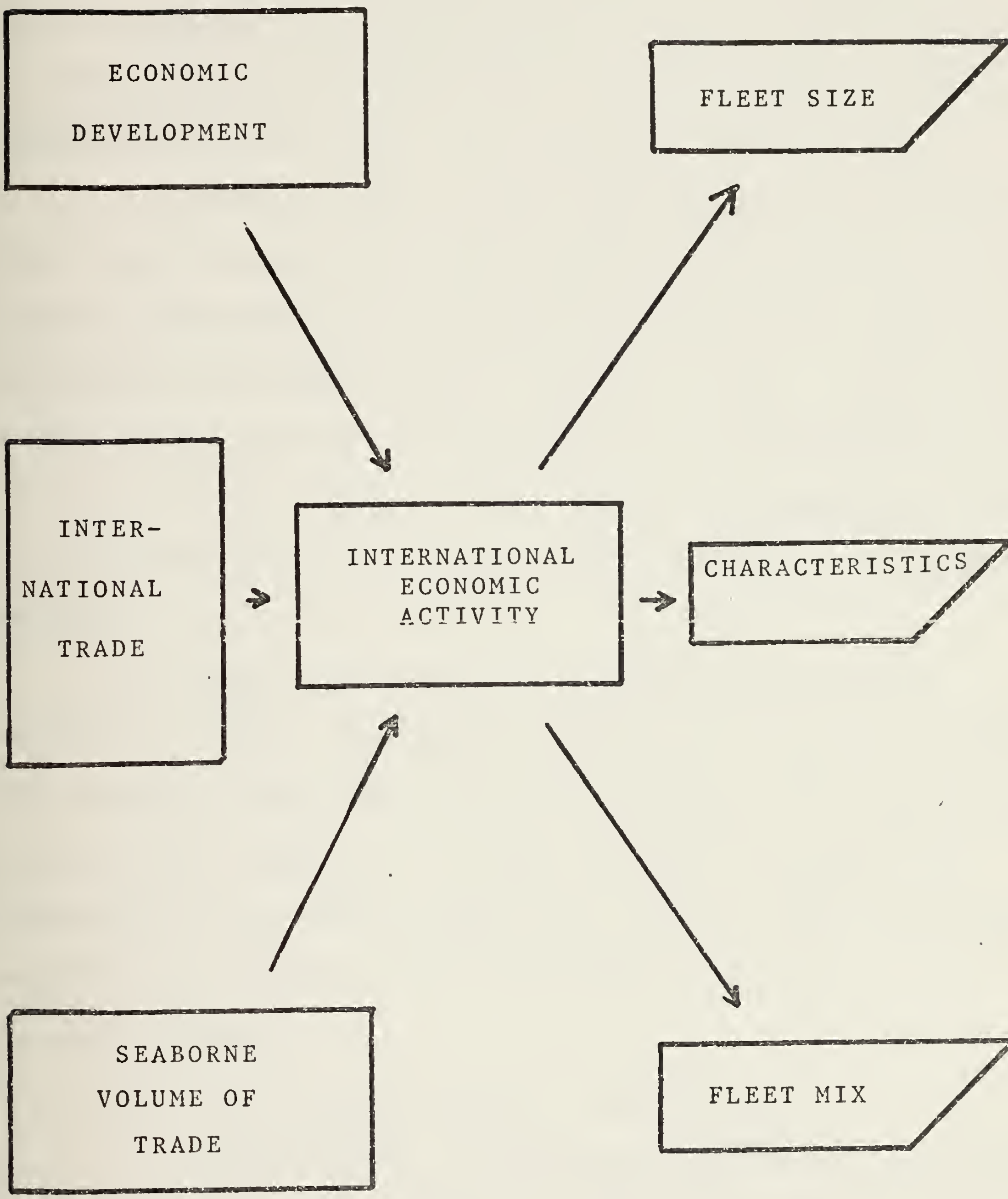

FIGURE V-4

provided the necessary prior status to represent a causal model. Although the use of partial correlational analysis could have been conducted to establish the causal relationships, because of the application of regression analysis to forming predictive equations, causal relationships were established on the basis of regression analysis alone.

In testing Model I two separate sets of variables were chosen to represent the concepts. In the first series economic development was represented by N05, the trade and development variable from the factor analysis. N17, military personnel per hundred thousand population represented the military effort concept, and the military capability concept was represented by N23, also a result of the initial factor analysis.

In the second series of analyses the military capability concept was operationalized by a sum of the other two variables, N05 + N17, to form a new variable designated N39, military capability. That military capability is represented by a sum of a nation's military effort and its economic development is an intuitively appealing conceptualization.

a. The General Results - All Nations

The results of regression analysis for all nations on the military model generally failed to reject the null hypotheses concerning the causal relationship between the military capability factor and merchant shipping of large maritime nations. In each variant of the Model more than 20

of the 38 dependent variables failed to be predictable to significant level (R^2 greater than .50). Examining the scores by individual dependent concepts, the Fleet Mix concept was the hardest hit with 87.5% of the equations failing to be predictive. The Ship Characteristics concept faired best with only 20% failures. Of note is the fact that all of the ship size variables produced predictable equations, therefore the individual null hypothesis that ship size is not explainable by military motivating factors for large maritime nations was rejected. The remaining dependent concept, Fleet Size, had 70% of the dependent concepts produce non-predictive equations. Of note here was that total DWT of a nation was predictive in both variants of the model as were total DWT and numbers of tankers.

b. Results for Cases USA, USSR

Let us now consider the model for the individual nations of the study. Limiting the report to the US and the USSR, the most striking observation is the high value of predictability attained. The table below demonstrates this occurrence.

	USA	USSR
R^2 greater than .9	16	14
R^2 greater than .8	25	24
R^2 greater than .5	36	30
Total Number of Equations	38	38

These results reflect that nearly all of the variables were predictable in both the USA case and the USSR, suggesting the rejection of the null hypotheses concerning the relationship of merchant shipping to military factors. Comparing this with the less predictive results for all large maritime nations, consider the fact that these two are the world's military superpowers. Also the connection between economic development and military capability utilized in this model cannot be ignored as a source of predictability; the relevance of economic development is not limited to the military domain.

The eight equations of the USSR which failed to be predictive bear further examination. The Fleet Mix concept displayed three of these, representing 38% of the Fleet Mix indicators. These occurred in the bulk ship and freighter percentage categories, while the versatile combination passenger-cargo ship and the tanker percentage indicators scored very high with R^2 values greater than .87. The remainder of the low scoring values (4) were distributed about the various Ship Characteristics indicators. This represents only 20% of those indicators and hence does not preclude rejection of the related null hypothesis. The table below displays the percentage and number of successful equations in each dependent concept category.

MODEL I PERCENTAGE (NUMBER OF) SUCCESSFUL EQUATIONS
(R^2 Greater than .5)

	USA	USSR
Fleet Size	100%(10)	90% (9)
Fleet Characteristics	90%(18)	80%(16)
Fleet Mix	88% (7)	63% (5)
Overall	92%(35)	79%(30)

2. <u>The Political Model: Model II</u>

The political model for predicting merchant shipping was the most complex model developed. The focus of this model is on the international influence potential and its component measures as predictors of the various facets of the merchant shipping of a nation.

The four initializing concepts (far left side of Figure V-3) were operationalized in terms of the basic independent variables of the study. Variables were chosen on the basis of previous analyses combined with an effort to avoid multicollinearity of basic variables. The four chosen variables are described as follows:

1. Aid Effort: N34, economic aid as a percentage of GNP
2. International military influence effort: N33, arms exports as a percentage of GNP
3. LDC trade: N20, balance of trade with LDC's.
4. LDC trade interdependence: N37, exports to LDC's as a percentage of GNP

The political military influence effort concept was then operationalized as two composite variables, the sum and the multiplicative product of the first two variables. The two new variables were identified as N41 and N42 respectively. The reason both indexes were developed was that there was no

intuitive perception as to what type of combination would best represent political-military influence. To put it in conceptual terms, if a nation gave only economic aid and did not engage in arms exports, which would be more representative of the political-military influence effort? The sum would equal the economic aid effort alone; the product of these two indicators would be zero, indicating the "missing" part of the equation. Empirical correlation analysis of these two indexes indicated that they represented empirically different facets of political-military influence effort. Consider the all-cases, USSR, and USA correlation coefficients. Only one exceeded .50, the USSR, and this r was below .80, the established criterion of multicollinearity [Rai and Blydenburgh, 1973, p.232].

To establish an index of economic influence, the LDC trade and LDC trade interdependence indicators were added and multiplied to replicate the procedures above. The multicollinearity checks conducted showed these two indicators to be the same; the additive index, N43, was used for the analysis.

Influence potential was conceptualized as a composite of all of the component concepts previously introduced. The sum and the product of all the variables were computed to form possible indexes of this concept, identified by N45 and N46, respectively. Once again the multicollinearity check established that these two variables were essentially the same whether considered for the entire data set or by

individual nation. For further calculations, the additive index, N45, represented international influence potential.

Several separate but related causal streams were tested in this model. These causal examinations are best shown diagrammatically.

Variant I	Variant 2	Variant 3
AID(t-4) SHIP(t) MIL(t-4)	TRADE(t-4) SHIP(t) NEEDLDC(t-4)	POLY-MIL (t-4) → SHIP(t)

AID:	Economic aid effort (N34)
MIL:	Military influence effort (N33)
TRADE:	LDC trade level (N20)
NEEDLDC:	LDC trade interdependence (N37)
POLY-MIL:	Political-military influence effort (both N41 and N42)
SHIP:	The various facets of merchant shipping (D03-D40)

A fourth variant is best represented by the basic Model II diagram, including aspects of political-military influence effort (N41), economic influence (N37), and the aggregate indicator of international influence potential (N45), all lagged four years as in the other variants.

a. The General (All Countries) Results

Regression equations for all countries using Model II were generally unsatisfactory. Of the four variants of Model II tested only four equations of the 152 examined met the minimum R^2 of .50. These four equations were all indicators of the Ship Characteristics concept; however, as they represent only 20% of the Ship Characteristics

indicators, the related null hypothesis was accepted. All null hypotheses related to political motivating factors of all-nations merchant shipping were accepted on the basis of these results. Thus, no inference was established for causal relationship between international political influence effort of large maritime nations taken as a whole.

b. The Results for Cases USA, USSR

As with the military model the application of the political model was much more successful with individual nations than with all nations. Each variant of the model resulted in more predictive equations than had the all-nations regression analyses. In the case of the USSR the variable N37, LDC interdependence was deleted from the analysis of the final variant because of its high correlation with N41 (r=.83).

The results of these equations in terms of percentage of successful equations for each dependent concept are tabulated below. The numbers in parentheses indicate the total number of successful equations in each category choosing the most successful variant of the model.

MODEL II, PERCENTAGE (Number of) SUCCESSFUL EQUATIONS

	USA	USSR
Fleet Size	80% (8)	90% (9)
Fleet Characteristics	90% (18)	90% (18)
Fleet Mix	100% (8)	63% (5)
Overall Successful	89% (34)	85% (32)

The high percentage of successful equations led to the rejection of the general null hypotheses concerning the explanatory role of international political motivating factors for Soviet Merchant shipping.

Turning to a consideration of the USSR's predictive equations by dependent concept, the Fleet Mix concept faired the worst with only 63% or five of the eight total Fleet Mix indicators yielding predictive equations. The indicators, freighter % (numbers) of total, bulk % (DWT) of total, and bulk % (numbers) of total all were unsuccessful. Recalling the results of Model I, the military model, these same indicators were unsuccessful. It appears that as yet these indicators of the emphasis of the Soviets on these ship types remain largely unexplained by the individual models.

Comparison of the US and the USSR by variant of the model showed that in the case of the USA the final variant, representing the entire model, exhibited most (i.e., 27 or 34 equations) of the best predictive equations. The most predictive variant for the USSR was the economic influence variant with 28 of the USSR's 32 best predictive equations. Although one would hesitate to totally discount the input of Soviet military influence efforts on the basis of this analysis alone, the inference is suggested that the economic influence factors do outweigh the factors of military influence effort in the explanation of the various facets of Soviet merchant shipping. A more meaningful evaluation of

the relative importance of motivating factors is approached later in this section with a comparison of the various models.

3. The Economic Model, Model III

Several variants of the economic model were tested over all nations. For the first variant the entire model was operationalized in terms of basic concepts presented. Economic development was represented by N08, energy consumption. The international trade concept was represented by N05, the earlier derived TRADEVEL factor, while seaborne volume of trade was operationalized by N26, seaborne balance (tons exports - tons imports) of trade. These three initial concepts were lagged four years while the international economic interaction concept, operationalized by the previously derived NEEDLDC factor, N23, was lagged two years. This concept was postulated as an intermediate concept in a developmental sequence between the basic concepts and the resultant merchant shipping indicators.

The second variant combined the economic development indicator, N08, and the international trade indicator, N05, into two composite indicators of trade and development, N47, the sum of the two, and N48, the product of the two. The third variant involved the computation of two other composite indicators, the sum and product of all three basic indicators. The sum of N05, N08, and N26 was identified as N49, their product as N50.

The empirical independence of the measures used in each regression equation was demonstrated by low correlation coefficients for all nations. The diagramatic representation which follows summarizes the three variants of the model tested.

<u>Variant I</u>

```
Development (N08) →
Trade (N05)  →   Activity (N23) → Ship
Sea Trade (N26) →
```

<u>Variant II</u>

```
Development  (N47
   and        or     →
Trade         N48)
                      Activity (N23) → Ship
Sea Trade (N26)   →
```

<u>Variant III</u>

```
Development, (N49
Trade, and     or  → Activity (N23) → Ship
Sea Trade      N50)
```

a. The General Results - All Nations

The various variants of Model III proved it the most predictive model for all nations. Thirty of 38 dependent indicators of merchant shipping resulted in successful predictive equations. Of the eight non-predictive equations four were in the category of <u>Fleet Mix</u> indicators, and four were in the Ships <u>Characteristics</u> category. On the basis of these results, the null hypothesis stating that merchant shipping of nations is not explainable by the economic motivating factors is rejected. It is worthy of note that

during this analysis it appeared that one particular indicator, N48, a product of N05 and N08, was a very good indicator of the average age of the various ship types (r greater than .83 for all of the five ship age indicators). That this indicator of trade and development could be used for as a single predictor of ship age is of interest and importance to the policy analyst.

b. The Results for Cases USA, USSR

For the individual cases of the US and the USSR, testing of the indicators of the variants of the economic model demonstrated that multicollinearity would represent a big problem. The very high intercorrelations of the various economic indicators of these two countries resulted in a limited choice of variables with which the model could be tested. One variant for each country which passed the test of multicollinearity was finally used for regression analysis. These variants are displayed diagrammatically below.

<u>USA VARIANT</u>

Trade and Development (N47) → Economic Activity (N49) → Ship

<u>USSR VARIANT</u>

Sea Trade (N23) → Economic Activity (N50) → Ship

The results of these regression equations are displayed as follows.

MODEL III, PERCENTAGE (Number of) SUCCESSFUL EQUATIONS (R^2 Greater than .50)

	USA	USSR
Fleet Size	50% (5)	70% (7)
Fleet Characteristics	90% (18)	90% (18)
Fleet Mix	75% (6)	50% (4)
Overall Successful	76% (29)	76% (29)

On the basis of these results the null hypothesis concerning the explanatory utility of economic motivating factors on the various facets of USSR merchant shipping was rejected. Although the number of successful equations was less than for Models I and II, realize that only one variant of this model could be used due to problems of multicollinearity. The use of several equation sets in the other models increased the number of successful equations obtained.

The greatest success for both nations in the economic model could be found in the Ship Characteristics category. The least successful equations for the USSR were once again Fleet Mix indicators. The same three indicators were unsuccessfully explained by any of the three postulated models. At this point it is relevant to recall that the results of the all-factors regression equations yielded successes for two of these three indicators. One might infer that the application of all the factors, the military, the political, and the economic provide more predictive relationships than any factor taken separately.

In the next and final part of this section, all three models will be compared to establish the relative importance of the different motivating factors.

4. Model Comparison for Each Dependent Concept: Which is Best for Whom?

One of the key purposes of creating the models was the comparison of the various models to determine the relative importance of the military, economic, and political motivating factors in predicting merchant shipping.

Tables V-9 and V10 summarize the results of all the equations previously discussed. Table V-9 displays a breakdown of the number of successful equations and what percentage of total indicators in each basic dependent concept that number represents. The overall rcentage shows what proportion of the dependent variables were successfully predicted and as such represents an overall measure of effectiveness for each model.

Table V-10 displays another measure of effectiveness of the various models. This table was compiled by determining the best (highest R^2) predictive equation over all models for each dependent variable. The percentage in this table represents the proportion of all the indicators for which that model exhibited the best predictive equation. The percentage of best predictive equations represents another measure of the effectiveness of each model. These tables are further explained during the actual comparison of the models.

TABLE V-9

PERCENTAGE (NUMBER) OF SUCCESSFUL EQUATIONS FOR EACH MODEL

	Model I Military	Model II Political	Model III Economic	Total
ALL NATIONS				
Fleet Size	30%(3)	0%(0)	80%(8)	36%(11)
Ship Characteristics	75%(15)	20%(4)	90%(18)	60%(36)
Fleet Mix	13%(1)	0%(0)	50%(4)	21%(5)
Overall	50%(19)	10%(4)	59%(30)	46%(52)
USA				
Fleet Size	100%(10)	80%(8)	50%(5)	77%(23)
Ship Characteristics	90%(18)	90%(18)	90%(18)	90%(54)
Fleet Mix	88%(7)	100%(8)	75%(6)	88%(21)
Overall	92%(35)	89%(34)	76%(29)	86%(98)
USSR				
Fleet Size	90%(9)	90%(9)	70%(7)	83%(25)
Ship Characteristics	80%(16)	90%(18)	90%(18)	87%(52)
Fleet Mix	63%(5)	63%(5)	50%(4)	58%(14)
Overall	79%(30)	85%(32)	76%(29)	80%(91)

TABLE V-10

PERCENTAGE (NUMBER) OF BEST EQUATIONS AMONG COMPETING MODELS

	Model I Military	Model II Political	Model III Economic	Total
ALL NATIONS				
Fleet Size	10%(1)	0%(0)	70%(7)	80%(8)
Ship Characteristics	15%(3)	0%(0)	85%(17)	100%(20)
Fleet Mix	12%(1)	0%(0)	38%(3)	50%(4)
Overall	13%(5)	0%(0)	71%(27)	84%(32)
USA				
Fleet Size	30%(3)	70%(7)	0%(0)	100%(10)
Ship Characteristics	45%(9)	40%(8)	15%(3)	100%(20)
Fleet Mix	63%(5)	37%(3)	0%(0)	100%(8)
Overall	45%(17)	47%(18)	8%(3)	100%(38)
USSR				
Fleet Size	90%(9)	0%(0)	0%(0)	90%(9)
Ship Characteristics	30%(4)	25%(5)	40%(8)	95%(19)
Fleet Mix	50%(4)	13%(1)	0%(0)	63%(5)
Overall	50%(19)	16%(6)	21%(8)	87%(33)

a. The General (all nations) Comparison

Turning briefly to a discussion of the relative utility of the various models for all nations, Model III, the economic model provided the most predictive equations. Reading down the Model III column in Table V-9 demonstrates that for all dependent concepts, Model III was the most predictive. The overall measure for Model III, 79%, was the highest. Although these percentages cannot be read as an interval scale, assuming the validity of the research that produced this table, a rough ranking of the relative effectiveness of the models is inferred. For the all-nations analysis the economic model was the most effective, the military model the second, and the political model the least effective predictor of merchant shipping.

Examining Table V-10 for all nations reinforces the prior observations. The economic model exhibited most of the best predictive equations with the other models falling into the previously established rank order.

b. Model Comparison by Cases USA, USSR

On consideration of the tables for the USA and the USSR, the first observation that can be made is that all of the models were more successful for the USA than for the USSR. It would appear at first glance that the models better explain the USA. Several weaknesses of this research need now to be mentioned before further analysis is attempted. First, the researcher was unable to include one of the postulated economic motivators of Soviet merchant shipping, that

is, international financial status. Second, for the USA, only privately owned U.S. flag ships and government-owned shipping were included in these regression analys s. As was previously mentioned, too few cases for meaningful regression were available for the USECON category of ships, so that the economically important flags of convenience were deleted from these analyses. Finally, because of the lack of flexibility in choosing statistically independent measures for the economic model, only one series of equations was developed. In all other models, several variants increased the number and percentage of successful equations. These weaknesses do not invalid this portion of the study, but they represent cautions in interpretation of the results.

Comparing the three models for the USA and the USSR in Table V-9, rough rankings of the motivating factors can be approximated. On the basis of these tables alone, only small differences were observed. The largest percentage difference for the USA was 16%; for the USSR only 9% separated the top ranking political model from the bottom ranked economic model. Comparing these results with the all-nations percentages where the top ranking economic model exceeded the bottom ranking political model by 69%, clearly less faith can be placed in the order of the USSR results.

Turning to Table V-10 for another measure of model effectiveness, only slightly greater divergence is apparent. Keeping both measures of effectiveness in mind, a rank order for the USSR was determined to be first the

military model, then the political model, and finally the economic model. Comparing this with the USA, the same ranking was observed for the USA, the military, the political, and the economic.

A further comparison of the models by individual concept was of interest. A figure of merit for each model within each concept was drawn in the same manner as the overall measure of effectiveness was obtained. The first measure, percentage successful equations, revealed very little difference over each concept considered for the USSR. For the USA, the Fleet Size measures showed both the military and political models as highly successful, while the economic model was less so Ship Characteristics measures were equally predictable with all models. Fleet Mix indicators showed minor variation, of interest here is that model II had 100% successful Fleet Mix equations.

Turning to the best predictive measure of effectiveness, Table V-10, Model I was clearly the best predictor for USSR Fleet Size and Fleet Mix. Models I and II were essentially equally predictive for Ship Characteristics while Model III provided the best predictor by a small margin. For the USA Model II provided most of the best predictive equations for Fleet Size. Ship Characteristics indicators were about equally well predicted by Models I and II and the Fleet Mix variables by Model I. A summary of the rankings of each model by dependent concept is shown as follows.

RANK ORDER OF MODEL PREDICTIVENESS

	Model I Military	Model II Political	Model III Economic
USA			
Fleet Size	(2)*	(1)	3
Ship Characteristics	(1)	(2)	3
Fleet Mix	(1)	(2)	3
Overall	(1)	(2)	3
USSR			
Fleet Size	1	(2)	(3)
Ship Characteristics	(3)	(2)	1
Fleet Mix	1	(2)	3
Overall	1	(2)	(3)

*Parenthesis mean that there was very little difference between that rank and the adjacent rank also shown in parenthesis.

There was only one significant variation from the military, political, economic ranking. That was USSR Ship Characteristics. This comes as a surprise since the various Soviet ship characteristics of size, draft, and speed have been highlighted as likely having political or military motivations, rather than economic. This table shows that among the rankings listed it is the only one in which the economic model was the best predictor. A more detailed examination showed that the eight Ship Characteristics indicators for which Model III was the best predictor were all age, speed, and draft indicators. Four of the five ship *size* indicators were in fact predicted best by the military model, Model I; the remaining size indicator, notably tanker size, was best predicted by the political

model, Model II. So the economic model did provide the best overall predictor of Soviet Ship Characteristics with the notable exception of ship size which in all cases was best predicted by non-economic factors.

For the reader interested in further detailed analysis of this sort, a complete listing of all the equations used in this section is available from the thesis advisor.

F. TIME-SERIES ANALYSIS

Essentially the entire study undertaken was a time-series analysis. The data for each country studied was collected over a period of 24 years, 1950 through 1973. Up to this point, however, only a few portions of the research have concentrated on the temporal nature of the data, such as the temporal stability check of the factor analysis and the use of time lagged data to establish causal inference.

In this section the temporal character of the data was exploited. The description of trends and the determination of breakpoints of merchant shipping data were used to establish more predictive regression equations. The dependent data was transformed into averages of five and three years in an attempt to detrend or "smooth" the data to lessen the effects of year to year variations. Finally, the independent variables were transformed on the basis of temporal relationships to create new variables representing the rate of

change, and the residual of each data point from its five year average.[3]

1. <u>Time-Series Data Description</u>

One of the assumptions of this study which allows effective prediction on the basis of regression analysis is the assumption of continuity, that is, the faith that the same general environemnt in which the study was conducted will continue to exist through the point of prediction. Underlying this assumption is the belief that the long-term trends of the data will continue. One procedure for the determination of the existence of such trends is, ". . . <u>serial correlation</u>, used to determine whether and to what degree each successive score in a time-series depends on the preceding score," [Gurr, 1972, p.142]. This procedure was conducted on the merchant shipping indicators in this study.

For all-nations the serial correlation matrix resulted in very high correlation coefficients for all dependent indicators. Only three indicators exhibited an r less than .90. They are listed below with the corresponding correlation coefficient.

D26 Average tanker speed (r=.82)
D33 Combination ship (DWT) % (r=.84)
D34 Combination ship (numbers) % (r=.86)

[3]A more complete discussion of the various methods of time-series analysis may be found in Gurr, 1972, pp.141-149. Additionally, some of the techniques applied here are innovative and no precedence in the literature can be found.

The USA and USSR serial correlations resulted in even higher levels of correlation suggesting that for all-nations or individual nations, long term trends do exist.

To further establish the temporal stability of these trends, the time-period of the study was subdivided into four year periods and serial correlation was conducted. Although some lower levels of correlation were observed, on the whole, the trends were consistent over the various periods and no specific breakpoints were detected that could be generalized over the entire data set. For the USA and USSR data, several time periods presented abnormally low correlation levels in specific areas. These indicate possible breakpoints and bear further investigation. In the 1954 through 1958 time period, both the USA and USSR, Fleet Mix variables showed low year to year correlations. In the case of the USSR, also the freighter and combination ship Fleet Size indicators exhibited low correlation coefficients. The USSR fluctuations are explained by the fact that this was the time of the largest boom in Soviet merchant shipping. This was accompanied by a shift in emphasis. A perusal of the raw data will demonstrate this point. The combination passenger-cargo ship percentage from 1950 to 1956 decreased slowly from 14% to 11% of the total number of Soviet ships. In the next two years, that percentage dropped dramatically as much as it had in the previous six years to 8% of the total. It wasn't until 1966 that it had dropped another 3%, that is, the rate of decrease

after 1968 leveled out considerably. This certainly represented a breakpoint in Soviet ship type emphasis.

A second step in this analysis was to describe the trends of the data. The subprogram SCATTERGRAM of the SPSS package provided the means by which the dependent data was graphically displayed. Each dependent indicator was plotted versus time to describe the trends and allow the determination of temporal breakpoints for the various merchant shipping indicators. A detailed analysis of the scattergrams could provide basis for fitting various curves such as logistics curves, sine curves or exponential growth curves to the various merchant shipping indicators [Gurr, 1972, p.143]. Such a study would rival in magnitude and length this entire research. The main utility of the scattergrams for this research was as a means of screening the data for recent breakpoints from which time-selected regression analysis might be employed to better previously unsatisfactory or marginal results.[4]

The variable scattergrams were scanned to detect breakpoints and recently changing trends for indicators which had previously provided low R^2 values during the initial inductive-factor regression analyses. For the USA, there were two variables which met both of these criterion, D18, bulk ship DWT total and D19, bulk ship total numbers. To

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[4]The scattergrams for all dependent variables and each nation or nation-entity (16 total nation-entities by 38 variables) are available on request from the thesis advisor.

give the reader a feel for the magnitude of the breakpoints for these indicators, from 1957 to 1961, USA bulk ship total DWT rose dramatically from 543 DWT to an all-time high of 1123 DWT. At that time a sharp reversal in this trend occurred; a nearly linear decrease in total DWT of bulk ships continued until a 1973 level of 630 DWT was reached. The number of bulk ships experience a corresponding shift. The magnitude of this shift was only partially explained by the all-years analysis using the inductive factors, so in the hope of improving the previous R^2 value (to provide greater predictability), the regression analysis was again conducted using only the years after 1960. The results of the post-1960-only equations for D18 and D19 were R^2=.90 and R^2=.97, respectively. This compares with the original "best lag" results of .64 and .72 respectively.

For the USSR four variables met the dual criteria of previously low predictability and a sharp change in trends. These variables and their respective amounts of explained variance for the all-years and the selected time periods are displayed in tabular format below.

USSR R^2 VALUES (Amount of Explained Variance)

Dependent Variable	All-Years "Best Lag" Results	Selected Time-Period Results	Time-Period
D09, Total number of Combination ships	.55	.44	After 1957
D35, Freighter DWT % of total	.76	.64	After 1962
D36, Freighter numbers % of total	.50	.65	After 1962
D38, Bulk ship DWT % of total	.42	.49	After 1962

Only two of the selected time-period equations resulted in an improvement in predictability, one of which still did not reach the minimum criteria of success (R^2=.50) set forth in the research. Overall, it seems that these indicators were explained about as well (or as poorly) for the entire time period as they were when analyzed over the selected time-periods. It may be concluded that in general, for the USSR, the breakpoints were equally explained (or remained unexplained) by corresponding changes in the determinant factors.

2. New Variables: Averages, Rates of Change, Percentage Rates of Change, and Residuals

In this section the development of several new variables is discussed with the goal of establishing more predictive models.

a. Averages: "Detrending" or "Smoothing" the Dependent Data

The object of creating averages over various time spans is to reduce the effect of radical year to year fluctuations of the data. By this means the data may display more general trends which were not apparent in the raw data. Further, it was postulated that the smoothed data might provide more predictive results than the annual fluctuations not explained previously by the independent factors.

The focus of this portion of the study was on the merchant shipping variables with the main purpose of screening the data in the same manner as the selected time-periods analysis was conducted. Averages over three-year and five-year periods were computed for all dependent variables. The

three year averages were taken from the middle three years of each case and the five year averages over all years in each case so that each average represented the middle year in the case. When these average values were regressed against the independent variables, an effective two year lag was developed from the middle year of each case.

For the all-cases analysis, 23 of the new variables were analysed using the inductive factors to determine whether these factors were more predictive of the smoothed variables than the raw data points. Of the 23 equations, 12 were more predictive indicating that although some practical advantage was gained in the exercise, only about half the equations were actually improved by using the smoothed values, about half were not as good.

For the cases USA and USSR the previously low predictive equations were tested with the smoothed dependent variables. Additionally where recent breakpoints were indicated only the post breakpoint years were used.

For the USA the smoothed and time-selected equations resulted in greatly improved predictiveness. For the USSR, however, the results below were ambiguous.

SMOOTHED DEPENDENT VARIABLE REGRESSION RESULTS

	R^2 Values		
USA:	Raw Data "Best Lag" Equation	Smoothed (& Time Selected) Equations	Years
D09, Number of Combination Ships	.81	.93	All
D13, Number of Freighters	.91	.94	All
D23, Number of Tankers	.78	.67	All
D29, Combination Ship Size	.69	.94	After 1954
D30, Freighter Ship Size	.93	.96	After 1961
D33, Combination Ship (DWT) % of Total	.51	.82	After 1961
USSR:			
D08, DWT of Combination Ships	.79	.37	After 1962
D37, Bulk Ship (DWT) % of Total	.47	.65	After 1964

b. Rates of Change, Percentage Rates of Change and Residuals

The next steps of the analysis focused on the creation of new independent and dependent variables on the basis of their temporal characteristics. Up to this point the researcher had created some 98 variables for each lead year in each case. Since each variable was replicated for the four preceding years and included in each case for the purpose of lagging, a total of 490 variables were listed in each case. A maximum of 500 variables is allowed in an SPSS file. In order to add new variables, some of the other variables had to be deleted. These were deleted on the basis of

the original factor analysis; independent variables were deleted which had shown very high correlations with other independent variables.

Sixteen independent variables (300 total per case) of the original 38 were retained and subsequently transformed. Rates of change were created by taking five year differences and three year differences in variable values to develop four year and two year rates of change. The new variables were identified by a D4 or D2 prefix to indicate the number of years over which the differences were computed. The examples below best depict the method and notation used.

D2N01(2 year rate of change, imports) = TA1N01(lagged 1 yr) - TB1N01(lagged 3 yr)

D4N01(4 year rate of change, imports) = TA2N01(current yr) - TB2N01(lagged 4 yrs)

The percentage rate of change of each variable was computed by dividing the previously determined value for the rate of change by the average of that value over the years considered. Multiplying this value by 100 provided the percentage rate of change, identified by a PR (Percentage Rate) prefix added to each variable.

$$PRN01 = (100)\ \frac{D4N01 \text{ (4 year rate of change of N01)}}{V5N01 \text{ (Average of N01 over the 5 years involved)}}$$

The essential difference between the percentage rate of change (PR) and the rate of change (D4) can best be demonstrated by these hypothetical cases.

HYPOTHETICAL CASES

Variable	Case I	Case II
TA2XX (Year 5)	1005	20
TB2XX (Year 1)	995	10
V5XX	1000	15
D4XX	10	10
PRXX	$(100)\ \frac{10}{1000} = 0.1\%$	$(100)\ \frac{10}{15} = 66.7\%$

As can be seen by the two cases, although the rates of change for variable XX (D4XX) were identical, the percentage rates of change (PRXX) differed greatly for the two cases.

The final new variable created was the residual of the five year average. Taking the middle value of the five year period and subtracting from it the five year average yielded a new variable identified by the prefix R5 (Residual of the five year average). The intention here was to create a variable which would operationalize the amount and direction of the fluctuation of a variable about its "smoothed" average over five years. The new variables tended to accentuate fluctuations and predict changes in trends and, although no precedent could be found in the literature, this method was hoped to provide improved predictiveness in some of the regression analyses.

The new variables were then described as had been their untransformed predecessors by the standard statistics such as the mean, standard deviation, skewness and kurtosis. A total of eight variables required

normalization prior to further analysis; on application of the appropriate function, the transformed variables yielded satisfactory values of skewness and kurtosis.

The dependent variables were additionally displayed in scattergrams across the years. These scattergrams disclosed some interesting relationships, such as some nearly linear relationships with rates of change across time. However, since the main purpose of the research was to create a model on the basis of motivating factors, these potentially predictive relationships were deemed the subject of some possible future analysis. As with the results of other analyses mentioned in this chapter, the complete scattergrams are available from the thesis advisor.

The final step in preparation for regression analysis was factor analysis. Twelve different factor analyses were conducted, one for each variable type on the entire file (all-nations) and for subfiles USA and USSR independently. Rather than go into a detailed description of each factor analysis, a summary of the studies is displayed in Table V-11. Under each variable type appears the major factor names and the variable chosen to represent the factor in further analysis. The factor names and choice of representative variables were made using the same procedures described in detail for the untransformed variable factor analysis.

In general, the transformation of the variables created a more diverse data set, exemplified by larger numbers of factors in each analysis. Although some factors

TABLE V-11
FACTOR ANALYSIS RESULTS OF TIME-TRANSFORMED VARIABLES

	D2 (Rate of change, two years)	D4 (Rate of change, four years)	PR (Percentage rate of change)	R5 (Residuals)
All Nations	N32 Energy Usage	N30 Energy Usage	N30 Energy Usage	N08 Energy Usage
	N05 Size	N05 Size	N14 Economic Aid	N23 Int'l Influence
	N34 Economic Aid	N14 Economic Aid	N20 Trade Balance	N20 Trade Balance
	N11 Military Effort	N20 LDC Trade	N16 Mil. Effort	N14 Economic Aid
		N17 LDC Importance		N16 Military Effort
USA	N30 Indust. Prod	N30 Indust. Prod	Weak correlations considered unsatisfactory	N17 Military Effort
	N05 Economic Size	N08 Economic Size		N11 Military Funds
	N16 Military Effort	N16 Military Effort		N37 LDC Trade
	N37 Int'l Trade	N23 LDC Trade		N30 Economic Size
	N34 Economic Aid	N14 Economic Aid		
USSR	Weak correlations considerations unsatisfactory	N14 Economic Aid	N20 LDC Trade	N05 LDC Trade
		N17 LDC Influence	N33 LDC Influence	N37 LDC Importance
		N37 Int'l Trade	N34 Economic Aid	N11 Military Effort
		N32 Economic Size	N08 Economic Size	N09 Economic Size
				N10 Military Size

were consistent for all of the transformed variables, sufficient differences were noted to conclude that the various transformations had created essentially different data sets. On consideration of the unsuccessful analyses, recall that for the untransformed data neither the USA nor the USSR exhibited satisfactory factor solutions.

2. <u>Regression Analysis with the Temporally Transformed Variables</u>

With the variable preparation and factor analysis completed, the next step of the research was regression analysis with the temporally transformed variables. Essentially the same steps were followed as had been with the untransformed variables with one exception. In the causal analysis portion of the study, only preminary steps were taken with Model I, the military model. Partial correlations were undertaken with this model, and as those results cannot be directly compared with the regression results conducted on Models II and III, no comparative analysis of motivating factors is included in this section.

On consideration of the all-nations regression analysis with inductive factors, the most striking feature is that the transformed variables produced more predictive equations than the untransformed variables. The percentage of success table below demonstrates this observation.

PERCENTAGE (Number) OF SUCCESSFUL EQUATIONS, ALL-NATIONS
(R^2 Greater than .50)

	Untransformed	Temporally Transformed
Fleet Size	80% (8)	90% (9)
Ship Characteristics	85% (17)	100% (20)
Fleet Mix	38% (3)	38% (3)
Overall	74% (28)	84% (32)

The superiority of the transformed variables held for all the dependent concepts except Fleet Mix, for which transformed and untransformed variables were equally poor predictors.

Comparison of like results for the USA and the USSR showed the same general pattern. Where the inductive factor utilization with untransformed variables left five indicators unexplained (R^2 less than .5), for the comparable transformed variable regression, 100% of the indicators were explained for both the USA and the USSR.

Referring to a previously used method of measuring the effectiveness of models, the same method was applied to measure the relative effectiveness of using transformed or untransformed variables in regression. The results are displayed by the table below. High scores (greater than 50%) favor transformed variables. Untransformed scores may be obtained by subtracting the percentages below from 100%.

PERCENTAGE (Number) OF BEST PREDICTIVE EQUATIONS FOR TRANSFORMED VARIABLE REGRESSION EQUATION WHEN COMPARED TO UNTRANSFORMED VARIABLES

	USA	USSR
Fleet Size	0% (0)	60% (6)
Ship Characteristics	70% (14)	85% (17)
Fleet Mix	12% (1)	100% (8)
Overall	39% (15)	82% (31)

From the overall scores in the table one may conclude that transformed variables produce more predictive equations for the USSR while the opposite is true for the USA. In the case of the USA the Ship Characteristics are also more predictable by the transformed variables.

In conclusion, the time-series analysis provided improved the overall prediction capability of the study. In the next section specific examples of the best predictive equations over all the methods will be applied.

VI. SUMMARY OF RESULTS: THE BEST PREDICTIVE EQUATIONS FOR THE USSR

In this brief chapter, the research will be summarized in terms of the development of the best predictive equations for USSR merchant shipping attributes obtained from the entire research. The best predictive equations were chosen on the basis of the general measure of effectiveness, R^2 (coefficient of multiple determination). At each step of the research other measures of equation effectiveness, such as the S.E. (Standard Error of the Equation), the equation F statistic, and the individual variable significance were scrutinized and met acceptable minimum criteria. Therefore, the R^2 values obtained were valid measures of each equation's relative merit.

A. COMPARISON OF PREDICTIVE METHODOLOGIES AND DATA HANDLING TECHNIQUES

A complete listing of the best predictive equations is available in Appendix D. In the following paragraphs the best predictive equations are analyzed by general methodology and technique.

First, consider the overall comparison of the use of <u>inductive factors</u> for prediction with the use of <u>models</u> in this research. The table below summarizes the percentage of the best predictive equations obtained from each method.

BEST PREDICTIVE EQUATIONS PERCENTAGE
(Number) BY SOURCE METHODOLOGY

	Inductive Factors	Causal Models
Ship Size	50%(5)	50%(5)
Ship Characteristics	70%(14)	30%(6)
Fleet Mix	37%(3)	63%(5)
Overall	58%(22)	42%(16)

The overall values displayed little difference in the methods. However, for the prediction of Ships Characteristics, the use of inductive factors is superior. We have somewhat less confidence that causal models are the better methodology for Fleet Mix variables.

The next step of this analysis was a comparison of the two basic data-handling techniques, using untransformed variables versus the temporally-transformed variables. The table below summarizes a comparison of the two techniques disregarding the methodology used.

BEST PREDICTIVE EQUATION PERCENTAGE
(Number) BY DATA-HANDLING TECHNIQUE

	Untransformed Variables	Temporally Transformed Variables
Fleet Size	50%(5)	50%(5)
Ship Characteristics	15%(3)	85%(17)
Fleet Mix	0%(0)	100%(8)
Overall	21%(8)	79%(30)

These results infer that the temporal transformation of variables provided superior prediction. Only for Fleet Size variables were these results inconclusive.

One might consider controlling for the technique to determine the value of the methodology or vice versa. A preliminary cross-tabulation of the techniques versus the methodologies is displayed below.

CROSS-TABULATION OF METHODOLOGIES AND TECHNIQUES RESULTING IN BEST PREDICTIVE EQUATIONS

	Untransformed Variables	Transformed Variables	Total
Inductive Factors	3	19	22
Causal Models	5	11	16
Total	8	30	38

Although it might appear that significant relationships exist between the methods and the techniques, a Fisher's exact test yielded a probability of .17 that this distribution was the result of random variations. The normally accepted maximum probability to establish significance is .05, therefore, further analysis was deemed unlikely to yield significant results. With respect to predictive capability, no significant relationship between the methodology used and the data handling technique was concluded.

B. APPLICATION OF THE PREDICTIVE EQUATIONS: SOME SAMPLE PREDICTIONS

The purpose of this section is to demonstrate the usage of the predictive equations by making predictions on the basis of several equations chosen from the complete list in Appendix D. The equations were selected on the basis of sampling the three dependent concepts, Fleet Size, Ships

Characteristics, and Fleet Mix. Also, the two major data handling techniques are represented.

1. The Fleet Size Sample Equation

The sample of the Fleet Size equations is D03, Total DWT of the Soviet Maritime Fleet.

$$D03 = 11.79088TB2N39 + 518.27731$$

The coefficients above are b coefficients and can be used with raw data. In this case TB2N39 is a composite indicator of military capability, composed of the sum of TB2N05 (LDC imports), and TB2N17 (military personnel per 100,000 population).

This equation represents one of the few simple linear regression equations developed during this research. It was derived during the testing of the military capability model and exhibited the highest R^2 (R^2 = .98) of any of the 60 or so equations developed for D03.

To use the equation one must simply obtain the latest data available for the independent variable and enter the single value into the equation.

TB2N39 is lagged four years to provide an estimate four years ahead of the current data available. The values are shown below.

Variable	Value	Year
N05	1520	1972
N17	7	1972
N39	1527	
D03	19,820DWT (thousands)	1976 (estimate at the end of that year)

A review of the figures for total DWT of the Soviet Maritime Fleet will show these estimates represent a continuation of recent trends.

DWT TOTAL OF SOVIET MARITIME FLEET
(Estimates in Parenthesis)

End of Year	DWT
1969	12757
1970	14302
1971	14858
1972	15413
1973	16507
1974	(18523)
1975	(18712)
1976	(19820)

The key difference between this method and a simple trend extrapolation is that the figures are produced on the basis of current indicators. There is no inherent reliance on the continuation of merchant shipping trends; only the continued relationship between the key determinant factors and merchant shipping is assumed.

2. <u>The Ship Characteristics Sample Equation</u>

D26 = .0276D4N26 + .02075D4N32 + 22.49425

D26: Average tanker age
D4N26: Balance of seaborne trade (4 year change)
D4N32: Energy production per capita (4 Year change)
Equation R^2 = .998
Equation source: Transformed variables economic model

The equation shown above represents a <u>Ship Characteristics</u> indicator with a very high R^2 value. The use of the D4 (4 year rate of change) variable does limit the

predictiveness, which for this data set, only represents a one-year prediction from the most recent independent values available. The results are shown below.

Variable	Value	Year
D4N26	-482	1973-1969
D4N32	75.32	1973-1969
D26	(11.6 yrs.)	1974

The recent values of D26 are as follows:

D26	Year
14	1970
13	1971
13	1972
(12.4)	1973
(11.6)	1974

3. The Fleet Mix Sample Equation

$$D40 = .00042D2N30 - 3.22885D2N17 - .00273D2N20 - .0015D2N14 + 7.7261$$

D40: Tanker percentage (numbers) of the total fleet
D2N30: Population Energy product (Millions persons · metric tons of coal equivalent) - 2 year change
D2N30: Military personnel per 100,000 population (2 year change)
D2N20: Balance of Trade with LDC's (Million $) - 2 year change
D2N14: Economic Aid (Million $) - 2 year change

Equation R^2: .95
Equation source: Transformed variable (D2) inductive factors

Replicating the processes used in the other two dependent concept sample equations, the equation above was

used for prediction. Note that this provides a two year prediction ahead of the middle value of the rate of change (D2) variables.

Variable	Value	Year(s)
D2N30	39231	1973
D2N17	-1	1973
D2N20	+290	1973
D2N14	-152	1973
D40	(19.1%)	1975

The estimate of the percentage of tankers in the Soviet fleet at the end of 1975 is 19.1%. Although this represents a slight change from recent values (roughly 20-21% for the last six years), the actual truth of the prediction remains to be seen.

VII. CONCLUSIONS

> Facts, or what man believes to be facts, are delightful . . . . Get your facts first, and then you can distort them as much as you please.
>
> Mark Twain
> [Kipling, From Sea to Sea, Letter 37]

It is not the purpose of this section to merely replicate the statistical results of the research for the reader's personal interpretation. Rather, the substantive and methodological findings made at various points in the study are summarized and expanded to facilitate an overall view of the study. Further, a discussion of the practical applications as well as the limitations of the research is followed by a brief look at the future possibilities of research of this type.

A. THE SUBSTANTIVE FINDINGS OF THF RESEARCH

The basic purpose of this thesis was to predict and explain the various facets of Soviet Merchant shipping on the basis of political, military, and economic factors. Examining the preliminary historical analysis, these factors were postulated as determinants of Soviet Merchant Shipping, with some intuitive statements about their relative importance. The subsequent statistical analysis was undertaken with the purpose of establishing the existence and nature of these hypothesized causal relationships.

1. Bivariate Analysis

Examining the bivariate correlation matrices, strong correlations were observed between the dependent concepts and the independent indicators. Although bivariate correlations alone do not infer causal relationships, these preliminary results using both time-lagged and time-led independent data reinforced the justification for further analysis.

Additionally, the each-nation correlations were generally higher than those obtained for the entire file, suggesting that explanatory models for each nation might be better predictors than a more general model.

2. Factor Analysis

For this study, the major purpose of factor analysis was to reduce the data and to inductively identify the underlying factors of the independent data set. Later analysis required reducing the number of variables to ensure the statistical and theoretical reliability of the results.

Factor analysis of the original 38 variables yielded four major factors for the all-nations analysis. These four factors strongly reinforced the initial concepts of the operational definitions of military, political, and economic factors. Further analysis of a subset of these variables justified the use of a representative variable for each factor in this study and established the face validity of the factor identification.

3. Regression Analysis: Inductive Factors

Regression analysis with the inductive factors was the first procedure from which causal relationships could be derived. Time-lagging the independent variables in the regression process established the necessary prerequisites for causal inference. Time-leading the independent variables was useful for determining the feedback effects of merchant shipping on the independent indicators.

a. All-Nations Analysis

All-nations results demonstrated that lagging the factors over an increasing number of years improved the predictive equations. This strengthened the postulated causal inferences of the basic analysis. Further, time-lead equation results showed that feedback relationships were present, in most cases stronger than the lagged results. The conclusion is that the military, political, and economic characteristics represented by the factors are in fact resultants as well as determinants of merchant shipping indicators.

b. USA, USSR Analysis

Analysis of the USA and the USSR using inductive factors was hampered by problems of multicollinearity. Since in many cases only one variable could be used in the equation, only very rough factor comparisons were possible. Despite the fact that fewer variables were used, higher R^2 values resulted from the each-nation analysis than from the all-nations regressions. Null hypotheses concerning the effects

of all factors considered together on Soviet merchant shipping were rejected with confidence.

4. Causal Analysis

The major purposes of the causal analysis were: (1) to examine causal relationships between merchant shipping and the various economic, political, and military models, and (2) to determine the relative importance of these factors.

Summarizing the overall results for the all-nations analysis, the international economic activity model was most predictive with the military capability model and the international political influence model trailing, in that order.

During the testing of the international economic activity model for each nation, the problem of multicollinearity among the various economic indicators prevented using multiple variants of this model. For other models the use two or three variants had slightly improved their effectiveness. Although this should have minimal effect on the validity of the model-comparison method, some caution is advised in interpreting the results for each nation.

The ranking of the models on the basis of overall effectiveness for the USA and the USSR was the same for both nations. The military capability model ranked first, the international political model ranked second, and the international economic activity model was the least predictive. This result was not expected. Particularly for the USA one would expect economic factors to decisively dominate. However, consider that the USA merchant shipping data consists

only of U.S. Privately-owned and government owned shipping (reserve fleet, not naval auxiliaries). Recall that the USECON indicators developed had too few cases for regression analysis. This note lends more credibility to the equivalent rankings of these two nations. Finally, consider that the intervals between rankings for the each-nation comparison were much less definitive (smaller percentage spread) than the all-nation results.

When examined by individual dependent concept the overall model ranking was maintained for the USA and for the USSR with the exception of the USSR Ship Characteristics. The International Economic Activity Model was the best predictor of Soviet Ship Characteristics, another conclusion which contradicts many expert's intuitive conclusions about the causal factors of this facet of Soviet Merchant Shipping. The most popular hypotheses state that although the Fleet Size and Fleet Mix concepts might be best explained by economic factors, certainly the Ship Characteristics (size, speed, draft) would be better predicted by non-economic factors. This concept bears further consideration.

A detailed examination of the USSR Ship Characteristics results show that all of the five ship size indicators were in fact explained by non-economic models. Four of these were explained the military capability model, the fifth, tanker size, was best predicted by the International Political Influence Model. The remaining 15 Ships Characteristics (age, speed, draft) were best predicted by the International

Economic Activity Model, accounting for the indicated decisive superiority of this model in predicting overall Ship Characteristics.

5. Time-Series Analysis

In the time-series analysis the temporal nature of the data was exploited. Trends were examined for the dependent variables; the independent variables underwent transformation on the basis of temporal relationships. Subsequently, these new independent variables underwent the entire gamut of statistical analysis, factor analysis, regression analysis, and causal analysis.

a. Serial Correlation and Data Smoothing

Serial correlation of the merchant shipping indicators of all-nations data revealed that long term trends exhibiting temporal stability do exist.

For the USA and the USSR certain breakpoints or sharp changes in trends of the merchant shipping data were discovered. On the basis of serial correlation and scattergrams (time versus shipping variables), the recent breakpoints were exploited by reanalyzing previously poorly explained variables (low R^2). Regression analysis with the inductive factors for only the post-breakpoint years yielded greatly improved results for the USA. On the other hand, for the USSR this analysis gave no improvement. The USSR breakpoints in merchant shipping trends were equally explained (or unexplained) by corresponding changes in the trends of the determinant factors.

Smoothed merchant shipping data, three and five year averages, were subjected to the same screening procedures. Reapplication of regression analysis to 23 all-nations variables yielded 12 improved predictions. For the USA analysis a significant improvement in equation predictiveness resulted, while for the USSR the results were ambiguous. The inductive factors explained the USSR year-to-year fluctuations about as well as they explained smoothed data points. All of the above demonstrates the need to have substantive knowledge about the history of shipping in order to evaluate break-points.

b. Temporally Transformed Independent Variables

The independent variables next underwent various transformations to create rates of change, percentage rates of change, and residuals from the five year average. The transformed variables were then subjected to the same statistical processes as had been their untransformed predecessors.

Factor analysis demonstrated that the transformed variables represented a more diverse data set, with more factors created from the all-nations analysis. Additionally, the USA and the USSR exhibited distinct inductive factors for three out of four of the transformed data sets. Recall that factor analysis had failed for individual nations using untransformed variables.

Regression analysis was performed with representative transformed variables (i.e., inductively derived

factors). These analyses yielded more predictive equations than had the untransformed variables for the all-nations and the USSR cases. For the USA no improvement resulted.

6. Summary Findings

The most important substantive findings are enumerated below:

a. Soviet Merchant Shipping is well explained by the economic, military, and political factors when those independent measures are combined or considered separately.

b. Although military, economic, and political models were all quite effective predictors of Soviet shipping, the relative ranking of these factors was: (a) military, (b) political, and (c) economic. This ranking was comparable to the USA results.

c. The concept Soviet merchant Ship Characteristics was an exception to the above-listed ranking. All Ship Characteristics indicators were predicted by the economic model with the exception of ship size variables. Tanker size was best predicted by the political model, and all other size measures by the military model.

d. Breakpoints in Soviet Merchant Shipping trends are well explained by corresponding changes in the determinant factors. For the USA, these relationships were not as consistent.

B. THE METHODOLOGICAL ASPECTS AND APPLICATIONS OF THE STUDY

The conclusions and predictive equations of this research are the results of the summarization of multiple streams of

evidence derived from multiple methodologies. The two primary methodologies of the research were (1) a traditional historical analysis and (2) a statistical analysis of major factors.

This section describes the limitations, applications, and comparisons of the statistical methodologies used in the study.

1. <u>Limitations of the Research</u>

a. The Statistical Assumptions

Although not to be considered as weaknesses of the research, there are certain theoretical assumptions which should be kept in mind during the application of the results of this study.

"Mathematical statisticians point out that statistical techniques only describe relationships, they do not explain them," [Gurr, 1972, p.16]. However, in the field of quantitative analysis certain conventions have developed, based on plausible assumptions, by which criteria certain statistical results are viewed as consistent with causal theories. That the independent variable regularly precedes the dependent variable is partial grounds for establishing a causal relationship. That this precedence represents a logical progression confirms the causal nature of the relationship. The use of time-lagged factors developed from previous research in regression analysis exceeds the minimum criteria normally required to establish causality.

The assumption of continuity is basic to this research. This assumes that basically the same environmental factors will exist through the time-period over which the prediction is made. The application of this assumption in this study is pertinent only to the relationships that exist between the predictive factors and the merchant shipping indicators. That is, the current trends of Soviet Merchant Shipping are not expected to remain consistent, only the established relationships between those trends and the trends of their determinant factors. The breakpoint analysis showed that for the USSR the continuity of predictiveness existed.

A possible break in the continuity of the relationships could occur. Consider the effects of the energy crisis. The USSR is currently self-sufficient in petroleum products, but is expected to be a net importer of petroleum by 1980 [Ackley, 1974]. This could change the predictive relationships, as could a change in the world financial system from the emphasis on conventional hard currency to an emphasis on "petrodollars."

Finally, only linear relationships were examined in this study. Economic growth models, exponential relationships, etc., have been used in the literature to describe many plausible causal relationships. Strictly speaking, this research has developed the best predictive <u>linear</u> equations for Soviet Merchant Shipping.

b. Data Limitations

The two nation-entities USMIL and USECON were not adaptable to regression analyses because of an insufficient number of cases. The innovation of USMIL (USA shipping plus effective US control shipping) and USECON (US privately owned shipping plus flag of convenience ships) was expected to yield unique relationships between these two facets of US shipping and USA independent factors. Additionally, these units should have been more directly comparable to Soviet shipping with respect to the predictive relationships examined. Hopefully, this capability will be pursued.

In the development of the independent factors, the major disappointment was the inability to adequately operationalize international financial status for the USSR. The addition of such an index could improve the predictive quality of the research and would certainly be of interest in testing certain hypotheses.

c. Practical Considerations

The computer programs were accomplished on an IBM 360 with the Statistical Package for the Social Sciences. Approximately 2500 separate regression equations were developed in the course of this research (not counting numerous discarded program errors), several factor analyses, several 76 by 190 variable correlation matrices, all amounting to three hours CPU time, numerous boxes of printout paper and about nine man-weeks (40 hour) of researcher

computer operations. That takes time and money! A part of this time was spent in the creation and debugging of the file, which need not be replicated, but the majority was spent in actual calculations. None of the researcher's time in data collection or analysis of the results is reflected in these figures.

2. Compative Methodologies and Techniques

The focus of this brief section is a summary of the results of the comparison of the two major statistical methodologies used and the two data handling techniques developed.

The two major statistical methodologies of this study were: (1) The development of inductive factors and their subsequent application to regression analysis, and (2) the application of deductively derived causal models to regression analysis.

Since the major goal of this research was to obtain predictive equations, the measure of effectiveness by which these methodologies were judged was the percentage (number) of best predictive equations obtained. The results of comparing the two methodologies was that no significant advantage was inherent in one or the other. The use of both, however, did improve the overall predictiveness of the study and helped satisfy the explanatory goal as well.

The two data handling techniques of the study were (1) raw data usage and, (2) temporal transformation of the variables (rates of change, etc.). The temproal transformation of the variables provided decisively superior prediction

capability, although some raw data equations were among the best predictive. As a further check, the independence of the methodology from the data handling technique was established.

3. Applications of the Study

The results of this study can be applied to the prediction and explanation of the important facet of Soviet maritime power, the Soviet Maritime Fleet. There are several organizations in the US Naval Intelligence Command with interests in this area, and the computer facilities available to make similar estimates. For current estimates, one need only apply the most recent independent indicators available to the equations in Appendix C.

Other U.S. Government agencies interested in predictions of this sort are the U.S. Maritime Administration and the Office of Maritime Affairs, U.S. Department of State. Note that the procedures used are applicable to studies of other maritime nations and complete data sets are available for the USA, USSR, the United Kingdom, and Japan. For the individual Soviet Bloc nations, only merchant shipping data is available; no independent variables were assembled.

An annual update of the data file (available from the thesis advisor) would be simple, and provide continuing checks on the predictive equations. The data is in SPSS format and as such can only be used with the SPSS system. SPSS is compatible with IBM 360 or CDC 6600 installations and requires only a limited background in computer programming

to operate. Many students learn to use SPSS with no formal training.

C. WHAT NEXT?

During the conduct of this research several limitations appeared. Likewise, several opportunities for further analysis were apparent. The researcher was unable to pursue these because of time constraints and the already massive nature of the study. In this section several of these possibilities are discussed with the goal in mind of creating better explanatory models of Soviet merchant shipping.

1. <u>Data Base and Case Construction</u>

Earlier in this report the possibility of operationalizing international financial status for the USSR was discussed. Additionally, indicators for internal political factors pose another possible concept which could be related to merchant shipping. Identifying and quantifying these internal factors would present a difficult problem, however, and the likely gains are small.

Another possible source of predictiveness is the analysis of ship movements, particularly if an annual index of traffic between LDC's and the USSR were developed. The LDC trade indicators in this study probably represent a near optimal measure of those operations, but they are based on dollar values and do not reflect the number of trips or ships involved. Ship-days in ports (of LDC's) represents another possibility in this area.

An analysis of a nation's port size and the size of major (or all) trading partner's ports would possibly better predict ship size and draft indicators, but such a measure would have to be weighted by the frequency or DWT of that nation's shipping using the port; another complex analysis of movements. Also port size data, although available, is of a static nature, that is, only a one-time port size cross-national analysis would be applicable. For the merchant shipping indicators, an expansion of the USMIL and USECON cases would likely provide better comparative cases for the USSR.

The single improvement most likely to achieve greater success with this data base would be to increase the lagging of data in each country-year. Rather than add whole years of variables (recall the 500 variable maximum), perhaps only even-year lags could be included. That is, use 0,2,4,6, and 8 year lags versus the 0,1,2,3, and 4 year lags used in this study. Since increasing lags generally increased the predictiveness of the equations, perhaps greater lags would result in even better equations. Additionally, the predictions could be of more value because of the greater range of the forecasts. Although this modification of the data set would require some time, no additional data need be collected. The only possible disadvantage of using greater lags would be the loss of cases when analysing individual nations, not a critical consideration for the USSR.

2. Methodology

Numerous methodologies could be applied to the data set. The first that comes to mind is the testing of non-linear relationships between the causal factors and the merchant shipping indicators. The SPSS package permits the usage of various funtions: square root, exponential, logarithmic, and trigonometric functions, to mention a few. The major danger in the application of these transformation functions is that the data may be distorted; on the one hand creating a poor representation of reality, on the other hand destroying the normal distribution of the raw data. Since a nearly normal distribution is an essential prerequisite for correlation analysis and all of the follow-on techniques built on correlations, the latter caution must be considered important.

Considering the time-series analysis, the methodology of trend extrapolation could be used to predict the merchant fleet. The assumption of continuity is, of course, critical to this method; furthermore, this methodology has no explanatory capability, and the prediction of breakpoints is difficult. The application of various growth curve models, logistics curves, and the like, have been successful forecasting techniques for other studies of a similar nature. The current data set is amenable to these applications and the preliminary work (scattergram display) has already been accomplished.

Clearly, the application of various methodologies to this data set is limited only by the researcher's imagination. The same can be said for application of the methodology developed here to many quantifiable phenomena of interest. With imagination, the sky is the limit.

APPENDIX A

FILE CONSTRUCTION AND UTILIZATION OF SSPS

Depicted on the following page is an abbreviated version of the original SPSS input data of one case. The identification of the years for each variable allowed comparing variables across the five year span without further file manipulation. The individual identification of each variable was accomplished by adding a lag prefix to the variable name, such as TA2 for "time ahead 2 years." As the analysis developed it became evident that the case could most conveniently be identified by the TA2-year instead of the TA0-year as was originally planned. All other years were then considered lag years. The case displayed is then UK (country code 020)-60.

CASE CONSTRUCTION

UK-1960

YEAR, COUNTRY, TOTAL DWT, # OF SHIPS, TANKER: AGE, SPEED, DRAFT

			CARD
TA2 - DEPENDENT	60020 251892	091329	#1
TA1 - DEPENDENT	59020 248812	101328	#2
TA0 - DEPENDENT	58020 239212	101328	#3
TB1 - "	57020 231732	101228	#4
TB2 - "	56020 230122	101228	#5

YEAR, COUNTRY, IMPORTS, EXPORTS, ECON AID, ARMS EXPORTS

			CARD
TA2 - INDEPENDENT	6002011530 9	63 165	#6
TA1 - INDEPENDENT	5902010060 9	13 141	#7
TA0 - "	58020 9360 8	30 255	#8
TB1 - "	57020 9790 9	63 193	#9
TB2 - "	56020 9590 9	33 136	#10

FIGURE A-1

CODEBOOK FOR ORIGINAL INPUT FILE TO SPSS

Variable Identification	Description	Card #	Cols
TA2D01	Year	1	1-2
TA2D02	Country Code	1	3-5
TA2D03	DWT overall	1	7-11
TA2D04	Number of ships	1	12-15
TA2D05	Average age	1	16-17
TA2D06	Average speed	1	18-19
TA2D07	Average draft	1	20-21
TA2D08	DWT combination ships	1	22-25
TA2D09	Number combination ships	1	26-29
TA2D10	Age combination ships	1	30-31
TA2D11	Speed combination ships	1	32-33
TA2D12	Draft combination ships	1	34-35
TA2D13	DWT freighters	1	36-40
TA2D14	Number freighters	1	41-44
TA2D15	Age freighters	1	45-46
TA2D16	Speed freighters	1	47-48
TA2D17	Draft freighters	1	49-50
TA2D18	DWT bulk ships	1	51-55
TA2D19	Number bulk ships	1	56-59
TA2D20	Age bulk ships	1	60-61
TA2D21	Speed bulk ships	1	62-63
TA2D22	Draft bulk ships	1	64-65
TA2D23	DWT tankers	1	66-70
TA2D24	Number tankers	1	71-74
TA2D25	Age tankers	1	75-76
TA2D26	Speed tankers	1	77-78
TA2D27	Draft tankers	1	79-80
TA1D01	Year (1 year back)	2	1-2
TA1D27	Draft tankers (1 year back)	2	79-80
TA0D01	Year (2 years back)	3	1-2
TA0D27	Draft tankers (2 years back)	3	79-80
TB1D01	Year (3 years back)	4	1-2
TB1D27	Draft tankers (3 years back)	4	79-80
TB2D01	Year (4 years back)	5	1-2
TB2D27	Draft tankers (4 years back)	5	79-80

Variable Identification	Description	Card #	Cols
TA2N01	Imports	6	6-10
TA2N02	Exports	6	11-15
TA2N03	Seaborne imports	6	16-20
TA2N04	Seaborne exports	6	21-25
TA2N05	LDC imports	6	26-30
TA2N06	LDC exports	6	31-35
TA2N07	Energy production	6	36-40
TA2N08	Energy consumption	6	41-45
TA2N09	Steel consumption	6	46-50
TA2N10	GNP	6	51-55
TA2N11	Military expenditures	6	56-60
TA2N12	Military personnel	6	61-64
TA2N13	Population	6	65-67
TA2N14	Economic aid	6	72-75
TA2N15	Arms exports	6	76-80
TA1N01	Imports (one year back)	7	6-10
TA1N15	Arms exports (one year back)	7	76-80
TA0N01	Imports (two years back)	8	6-10
TB1N01	Imports (three years back)	9	6-10
TB2N01	Imports (four years back)	10	6-10

All other variables used in this study were created after the establishment and storage of this original file on a magnetic disk. These 36 new variables (D28 through D40, N16 through N38) were computed by combining some of the original variables in the file, for example, GNP per capita (N29) equals GNP (N10)/population (N13). Further breakdown and definition of these variables is contained in Appendix B.

APPENDIX B

VARIABLE DEFINITIONS AND SOURCES

The definitions used for collecting the data on the 78 variables generally was adopted from the primary data sources.

The sources utilized are listed below along with abbreviations which will be used in the list of variables. The variable identification used in Appendix A will be used in this appendix without the lag prefix.

MARAD — A Statistical Analysis of the World's Merchant Fleets, U.S. Maritime Administration, A Bienniel report.

FORUS — Foreign Flag Ships Owned by United States Parent Countries, U.S. Maritime Administration, 1973, 1972, 1971, 1967, 1965.

EUSC — Ships Registered Under the Liberian, Panamanian, and Honduran Flags, U.S. Maritime Administration, 1970

MSC — Annex to MSC Ship Register, Military Sealift Command, 1974.

UNSY — Statistical Yearbook, United Nations.

DEMO — Demographic Yearbook, United Nations.

IMF — Direction of Trade, International Monetary Fund.

UNTRADE — Yearbook of International Trade, United Nations.

MILBAL — The Military Balance, Institute of Strategic Studies.

SIPRI — The Arms Trade and the Third World, SIPRI, 1967-1973.

ACDA — The International Transfer of Conventional Arms, ACDA, Sept. 1973. Arms Control and Disarmament Agency.

MAP — Military Assistance Facts, Office of the Assistant Secretary of Defense (International Security Affairs).

BRIT — British Aid Statistics.

CART — The Net Cost of Soviet Foreign Aid, Carter, James R., Praeger Publishers, 1971.

THE DEPENDENT VARIABLES

The breakdown of the merchant fleets in the various categories was the convention utilized by the U.S. Maritime Administration in recording and reporting merchant fleets of the world. Combination Passenger and Cargo Ships are ships with a capacity for 13 or more passengers; freighters includes containerships, car carriers, roll-on/roll-off, and LASH (lighter aboard ship or barge carriers); bulk carriers are bulk/oil, ore/oil, ore/bulk/oil carriers; and tankers include molten sulphur tankers, chemical tankers, liquefied petroleum and natural gas tankers (LPG and LNG), and whaling tankers.

The data included only those merchant type ships of 1,000 tons and over. Omitted were those operating exclusively on inland waterways and such special types as cable ships, icebreakers, trawlers, etc., and those actually owned by the military forces.

The variable listings are subdivided by major concepts as there is considerable continuity within concepts with respect to sources.

1. Overall Size of Fleet and Fleet Components

   a. Overall DWT (D03) millions of tons
   b. Overall number of ships (D04)
   c. Freighter DWT (D13)
   d. Freighter numbers (D14)
   e. Combination ship DWT (D08)
   f. Combination ship numbers (D09)
   g. Bulk DWT (D18)
   h. Bulk numbers (D19)
   i. Tanker DWT (D23)
   j. Tanker numbers (D24)

The above listed data was obtained from the sources, MARAD, FORUS, EUSC, and MSC.

2. Average Ship Characteristics

a. Ship size (average overall types) DWT (D28)
b. Combination ship size DWT (D29)
c. Freighter ship size DWT (D30)
d. Bulk ship size DWT (D31)
e. Tanker size DWT (D32)

The above listed variables were created from the appropriate previously listed variables, for example, D28=D03/D04. The aforelisted sources apply.

f. Overall ship age (D05)
g. Overall ship speed (D06)
h. Overall ship draft (D07)
i. Combination ship age (D10)
j. Combination ship speed (D11)
k. Combination ship draft (D12)
l. Freighter ship age (D15)
m. Freighter ship speed (D16)
n. Freighter ship draft (D17)
o. Bulk ship age (D20)
p. Bulk ship speed (D21)
q. Bulk ship draft (D22)
r. Tanker age (D25)
s. Tanker speed (D26)
t. Tanker draft (D27)

All of the age speed and draft measures were drawn from MARAD Biennial Reports from 1956 through 1973. Interim years were interpolated.

3. Fleet Mix

a. Freighter % (DWT) of total shipping (D35)
b. Freighter % (numbers) of total shipping (D36)
c. Combination % (DWT) of total shipping (D33)
d. Combination ship % (numbers) of total shipping (D34)
e. Bulk ship % (DWT) of total shipping (D37)
f. Bulk ship % (numbers) of total shipping (D38)
g. Tanker % (DWT) of total shipping (D39)
h. Tanker % (numbers) of total shipping (D40)

All fleet mix variables were computed by dividing the individual ship type value by the corresponding total for all types and multiplying by 100. For example:

D40=(D24/D04) x 100

Sources for the component variables apply.

THE INDEPENDENT VARIABLES

N01 Imports ($), source: UNTRADE, IMF, UNSY.
N02 Exports ($), source: same as N01.
N03 Seaborne imports (TONS), source: UNSY.
N04 Seaborne exports (TONS), source: UNSY.
N05 LDC imports ($), source: UNSY.
N06 LDC exports ($), source: UNSY.
N07 Energy production (metric tons of coal equivalent), source: UNSY.
N08 Energy consumption (metric tons of coal equivalent), source: UNSY.
N09 Steel consumption (metric tons), source: UNSY.
N10 GNP ($), source: SIPRI, MILBAL.
N11 Military expenditures ($), SIPRI.
N12 Military personnel, SIPRI.
N13 Population, DEMO, DIPRI.
N14 Economic aid ($), MAP, BRIT, CART.
N15 Arms exports ($), SIPRI, ACDA.
N16 Military expenditures as a percentage of GNP. Composite of N10 and N11. (N10/N11)
N17 Military personnel as a percentage of population. Composite of N12 and N13. (N12/N13)
N18 Balance of trade ($), composite of N02 less N01.
N19 Total trade ($), composite of N02 plus N01.
N20 LDC balance of trade, composite of N06 less N05.
N21 LDC total trade, composite of N06 plus N05.
N22 LDC trade as a percentage of total trade, composite of N21/N19.
N23 LDC imports as a percentage of all imports, composite of N05/N01.
N24 LDC exports as a percentage of all exports, composite of N06/N02.
N25 Total sea trade in tons, composite of N03 plus N04.
N26 Seaborne trade balance in tons, composite of N04 less N03.
N27 GNP per capita, composite of N10/N3.
N28 Arms exports as a percentage of total exports, composite of N15/N02.
N29 Energy shortage (metric tons of coal equivalent), composite of N08 less N07.
N30 Population energy product (person-metric ton of coal equivalent), composite of N07 times N13.
N31 Energy consumption per capita, composite of N08/N13.
N32 Energy production per capita, composite of N07/N13.
N33 Arms exports as a percentage of GNP, composite of N15/N10.
N34 Economic aid as a percentage of GNP, composite of N14/N10.
N35 Exports as a percentage of GNP, composite of N02/N10.
N36 Total trade as a percentage of GNP, composite of N19/N10.
N37 LDC exports as a percentage of GNP, composite of N06/N10.
N38 LDC total trade as a percentage of GNP, composite of N21/N10.

APPENDIX C

THE BEST PREDICTIVE EQUATIONS

On the following pages the best predictive (highest R^2) equations are listed in a form that the reader may use without further adjustment of the data. The equations use b coefficients and the variable labels are the same as those used in Appendices A and B. The additional prefixes and variables explained elsewhere in this research are listed for quick reference below:

1. Prefix:

   D2 = two year difference or rate of change of the variable; center year lagged two years from the dependent variable

   D4 = four year difference computed over the four years prior to the year of the dependent variable

   V5 = five year average of the variable

   PR = percentage rate of change of the four year difference

   $$100 \frac{(\text{D4xxx})}{\text{V5xxx}}$$

2. The "x" suffix:

   a. D18X is the symbol for the normalized D18 variable. To obtain "real" D18 values take the antilog of the results of the tabulated equation.

   b. PRN20X is the normalized variable for PRN20. Obtain the PRN20 value in the normal way and apply the following function:

$$\text{PRN20X} = \text{Log}_{10} \quad 3 + \frac{\text{PRN20}}{\text{1-PRN20}}$$

THE BEST PREDICTIVE EQUATIONS (HIGHEST R^2 VALUE)

	Equation	R^2 Value
D03	= 11.79088(TB2N39) + 518.27731	.98
D04	= 1.07203(TA1N05) + 420.95779	.96
D05	= -0.0006(D2N30) + 6.00324(D2N17) + 0.00555(D2N14) + 0.00982(D2N09) + 0.00713(D2N20) + 16.82181	.996
D06	= 0.00013(D2N30) - 1.378(D2N17) - 0.003(D2N09) - 0.00111(D2N14) - 0.00098(D2N20) + 12.91188	.997
D07	= 0.06686(D4N32) - 2.0486(D4N37) - 0.000119(D4N26) + 23.67783	.77
D08	= 361.66 - 22.81TB2N17	.80
D09	= 0.00015(D2N30) + 0.00879(D2N20) + 0.00475(D2N09) + 1.40701(D2N17) + 64.06357	.65
D10	= -0.88527(TA0N23) - 0.000001(TB2N50) + 33.21955	.97
D11	= 0.00009(D2N30) - 0.75372(D2N17) - 0.00173(D2N09) - 0.00667(D2N14) + 14.16984	.99
D12	= -0.0001(D2N30) + 0.84396(D2N17) + 0.00183(D2N20) + 0.00096(D2N14) + 0.00066(D2N26) + 20.1754	.99
D13	= -23.82165(RPN33) - 9.88668(RPN34) + 1150.2059(RPN20X) + 67.98365(RPN08) + 73825.29	.96
D14	= -3.31324(RPN33) - 1.31362(RPN34) - 169.93124(RPN20X) + 9.94256(RPN08) + 11044.33437	.94
D15	= -0.00066(D2N30) + 9.08699(D2N17) + 0.01256(D2N09) + 0.00513(D2N20) + 16.66592	.99
D16	= 0.00308(TB1N05) + 0.00113(TB2N33) + 10.00947	.98
D17	= 0.00008(D2N30) - 0.00167(D2N09) - 0.00051(D2N14) - 0.00044(D2N20) + 21.21065	.99
D18X	= 0.02013(D4N32) - 0.34825(D4N37) - 0.00011(D4N26) + 2.09303	.94

THE BEST PREDICTIVE EQUATIONS (Continued)

D19 = -0.39037(RPN34) - 0.00328(RPN33) + 3.37417(RPN08) + 1.67559(RPN20X)	.93
- 59.06114	
D20 = 0.01544(RPN34) - 0.0116(RPN33) + 0.37307(RPN08) + 0.0238(RPN10) + 5.00652	.82
D21 = -0.00268(RPN34) + 0.00167(RPN33) - 0.04406(RPN08) - 0.07063(RPN10)	
+ 14.63507	.94
D22 = -0.70422(D4N37) - 0.00055(D4N14) - 0.06823(D4N17) + 0.02948(D4N32)	
+ 20.95589	.97
D23 = 4.786(TB2N39) - 419.76968	.98
D24 = 0.33311(TB2N39) + 3.14503	.97
D25 = 2.08563(D4N37) - 0.5179(D4N32) + 0.00093(D4N26) + 7.32409	.99
D26 = 0.02716(D4N32) - 0.8365(D4N37) + 12.45205	.998
D27 = 0.00053(D4N26) + 0.02075(D4N32) + 22.49425	.74
D28 = -421.50565(D4N37) - 506.41857(D4N17) + 43.95873(D4N32) - 0.22703(D4N14)	
+ 4545.41	.99
D29 = 3.63942(RPN34) + 2.56679(RPN33) - 31.29126(RPN08) - 121.509(RPN20X)	
+ 73.9168(RPN10) + 8873.78587	.97
D30 = -3.31799(RPN34) - 7.94744(RPN33) - 4.98946(RPN20X) + 6004.59466	.93

THE BEST PREDICTIVE EQUATIONS (Continued)

D31 = 65.95659(D4N32) - 1354.06378(D4N37) - 0.69792(D4N26) + 4650.98095	.87
D32 = -1654.55348(D4N37) + 105.35449(D4N32) - 453.6182(D4N17) - 0.49371(D4N14) + 7317.34648	.997
D33 = -0.17822(D4N32) + 2.47491(D4N37) + 0.00151(D4N26) + 9.11991	.99
D34 = -0.14932(D4N32) + 2.2145(D4N37) + 0.00151(D4N26) + 10.29671	.98
D35 = -0.28722(D4N32) + 6.69196(D4N37) + 0.00120(D4N26) + 64.77143	.97
D36 = -3.55393(D4N17) + 2.64382(D4N37) + 0.00213(D4N14) - 0.12944(D4N32) + 74.94819	.75
D37 = 0.01254(D4N05) + 4.02714(D4N17) - 2.41556(D4N37) - 0.00149(D4N14) + 4.23922	.83
D38 = 0.03626(D4N05) + 3.64734(D4N17) - 2.42961(D4N37) - 0.00115(D4N14) + 5.30479	.87
D39 = -0.03626(RPN34) - 0.07741(RPN33) - 8.27435(RPN20X) + 530.20626	.993
D40 = 0.00042(D2N30) - 3.22885(D2N17) - 0.00273(D2N20) - 0.0015(D2N17) - 7.7261	.95

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